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INVESTIGATIONS CONCERNING THE TREATMENT OF AMŒBIC DYSENTERY

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INTRODUCTION

Amœbic dysentery is one of the more-important diseases caused by protozoa in which laboratory methods for the experimental study of its treatment have not yet been established. Many experiments, more or less isolated, have been recorded. In contradistinction to the work of Harris,(6) Vedder(16) showed that in vitro emetine is the active agent in ipecacuanha that is responsible for its toxic action on cultural amœbæ. Rogers(12) soon demonstrated, very convincingly, that emetine possesses a definite curative action in entamœbic infections in man. It seemed almost superfluous, therefore, to test the effect of emetine on lower animals. Dale and Dobell(3) in a very valuable paper and, later, Mayer(9) reported that emetine has no beneficial action in the treatment of amœbic dysentery in the cat.

Notwithstanding the striking benefit produced by emetine in amœbic infections in the majority of patients, the treatment still leaves much to be desired. The development of an appropriate laboratory method would facilitate the study of the effect of emetine or its derivatives and of other products in amœbic infections. This paper deals with: I. Experiments upon cultural

amœbæ in vitro; II. Results obtained in treating cats infected with *Entamœba histolytica;* and III. Clinical observations.

I. EXPERIMENTS UPON CULTURAL AMŒBÆ IN VITRO

Cultural amœbæ.—Considerable difficulty is encountered in testing and interpreting the effect of various agents upon amœbæ in vitro. The chief obstacle lies in the absence of any reliable method for the artificial cultivation of the pathogenic amœbæ. Indeed, it is not yet established that multiplication of the entamœbæ has been induced in vitro. Realizing these deficiencies, Vedder tested the effect of emetine on the non-pathogenic cultural amœbæ of the limax group. Bouillon diluted with water (1 to 20) was used, and the substance to be tested was added directly to this fluid culture medium before inoculation. Pyman and Wenyon(11) carried out similar experiments, using a solid agar instead of a liquid medium. These authors raise the question as to whether the drugs incorporated in the medium distribute themselves uniformly between the agar and the slight amount of fluid of synæresis on its surface.

Entamœba histolytica.—Many observers have tested, by direct microscopic examination, the effect of various substances on *E. histolytica.* This parasite, however, degenerates spontaneously, and with great rapidity, on removal from its host. The results with a given drug are often inconstant and irregular. As would be expected, the data of various workers are often divergent. Dale and Dobell report an exceptional instance in which amœbæ survived the action of emetine at 1 to 100 for a period of one hour. Rogers found that a dilution of 1 to 100,000 caused immobilization in a few minutes, the amœbæ being apparently dead.

The work here reported has been conducted entirely with a limax type of amœba. The substances tested were emetine, quinine, neosalvarsan, cholalic acid, benzyl benzoate, papaverine, *Castela nicholsoni* Hooker, *Tinospora rumphii* Boerläge, and some miscellaneous control substances. The amœba used was isolated originally from the stool of a healthy person. The stock cultures were kept on the usual agar medium using 15 grams of agar and 15 cubic centimeters of normal soda per liter of water. No attempt was made to isolate a strain of this amœba from a single cell nor to identify the mixture of bacteria growing with it. A fluid medium was prepared as follows: Peptone, 1 gram; sodium chloride, 1 gram; lactose, 1 gram; artesian water, 1,000 cubic centimeters. Varying dilutions of the agents

to be tested were prepared with this solution and, without sterilization, were immediately inoculated from a suspension of amœbæ from a twenty-four hour culture on agar. All incubations were made at 37° C. Observations were recorded at daily intervals until encystment of the amœbæ in the control cultures had occurred. A repetition of all tests was made with freshly prepared solutions. The results are recorded in Table 1.

TABLE 1.—*The inhibition of limax amœbæ in cultures by various substances.*

Substance tested.	Dilution.	Results.
Emetine hydrochloride	1-100,000	Bacteria only.
Do	1-1,000,000	Do.
Do	1-5,000,000	Occasional amœbæ.
Do	1-10,000,000	Numerous amœbæ.
Do	1-50,000,000	Do.
Quinine dihydrochloride	1-100,000	Bacteria only.
Do	1-500,000	Numerous amœbæ.
Do	1-1,000,000	Do.
Cholalic acid (from bile salt)	1-500	Bacteria only.
Do	1-1,000	Moderate number of amœbæ.
Do	1-5,000	Numerous amœbæ.
Benzyl benzoate (suspension)	1-10,000	Bacteria only.
Do	1-50,000	Do.
Do	1-100,000	Occasional amœbæ.
Do	1-500,000	Numerous amœbæ.
Do	1-1,000,000	Do.
Papaverine hydrochloride	1-5,000	Amœbæ (precipitation).
Do	1-10,000	Bacteria only.
Do	1-50,000	Numerous amœbæ.
Do	1-100,000	Do.
Neosalvarsan	1-500	Bacteria scanty.
Do	1-1,000	Bacteria only.
Do	1-5,000	Numerous amœbæ.
Castela nicholsoni	1-5,000	Bacteria only.
Do	1-5,000	Moderate number of amœbæ.
Do	1-5,000	Bacteria only.
Do	1-10,000	Numerous amœbæ.
Tinospora rumphii	1-100	Bacteria only.
Do	1-200	Numerous amœbæ.

It is impossible to compare the data in Table 1 with the results of other workers, on account of the variation in the species of amœbæ that were employed. It is clear, however, that Vedder's results are again amply confirmed.

Quinine, used as the dihydrochloride, exhibited a pronounced restraining effect on these cultures of amœbæ; of the substances tested it was second only to emetine.

In the absence of any bile salts, a specimen of cholalic acid was neutralized with sodium hydroxide. Its toxicity was rather low.

Papaverine was used as the hydrochloride, a salt which is only moderately soluble in water (about 1 to 37) and very much less soluble in physiological saline. Even the higher dilutions (1 to 5,000) prepared with this culture medium showed extensive precipitation. The results obtained were irregular, and duplicate tests showed considerable variation.

Benzyl benzoate is almost insoluble in water. Nevertheless, its suspensions in this culture medium inhibited the growth of amœbæ to a remarkable degree. Simpler benzene derivatives, ordinarily used to prevent bacterial decomposition, showed no such effect. Abundant growth of amœbæ was permitted by benzene itself in a suspension of 1 to 1,000; by toluene, at 1 to 1,000; and by xylene, at 1 to 10,000.

Tests with neosalvarsan are necessarily unsatisfactory, since solutions of this drug oxidize rapidly and increase in toxicity at room temperature. However, a dilution of 1 to 5,000 permitted free growth of amœbæ. In one of the tests a solution of neosalvarsan was shaken vigorously for fifteen minutes before diluting with the culture medium. The amœbæ grew just as well as in the corresponding dilutions that were not shaken. As would be expected, this initial increase in toxicity produced by shaking could not be detected by tests extending over a period of from one to three days.

An active principle of *Castela nicholsoni* was prepared by a method previously described.(14) This product was only slightly soluble in water. However, a dilution of 1 to 5,000 was usually sufficient to inhibit amœbæ.

Tinospora rumphii Boerläge contains an extraordinarily bitter principle. This plant is known to the Tagalogs as *makabuhay*, signifying "Giver of life." It is widely used in the Philippines. In India, there is a related species, *T. cordifolia* Miers; this name is given in the Indian Pharmocopœia, and the plant is used in the treatment of malaria and syphilis. A bitter principle of the Philippine species, was prepared by A. H. Wells, in charge of the division of organic chemistry of the Bureau of Science. It possessed only an insignificant action against the cultures of this amœba.

DISCUSSION

In chemotherapeutic work in amœbic dysentery, tests of toxicity of a drug for limax amœbæ are not without value for

the purpose of obtaining general orientation. Obviously, the results cannot be applied directly to *Entamœba histolytica* any more than the effects of experiments on lower animals can be applied directly to man. It is also perfectly clear that the effects in vitro do not imply a corresponding action in the animal body.

Vedder, as the result of his work with emetine on limax amœbæ, suggested that this drug in solution in the body fluids might be capable of killing or inhibiting *Entamœba histolytica* in the tissues of the intestinal mucosa, or even in the liver. Subsequent experience has amply justified this suggestion. In contrast to this, the entirely insignificant action obtained in vitro with *Tinospora rumphii* offers no encouragement for its use in amœbic infections.

II. RESULTS OBTAINED IN TREATING CATS INFECTED WITH ENTAMŒBA HYSTOLYTICA

Literature.—The treatment of amœbic dysentery in lower animals was undertaken with the purpose of developing a dependable method for the experimental chemotherapy of this disease. The infection of laboratory animals with *Entamœba histolytica* cannot be accomplished with ease and precision. Cats are ordinarily used, and the course of the experimental disease is best understood in the cat. Adult cats are not very susceptible to infection, and in kittens the disease usually assumes a fulminating type which obviously presents enormous difficulties in experimental therapy. This is well illustrated by the experience of previous workers. Dale and Dobell became discouraged in view of their failure to modify fulminating infections in kittens by treatment with emetine. They concluded that emetine has no direct action on *Entamœba histolytica,* either in man or in kittens; its undoubted therapeutic effect in man was ascribed, not to any direct action on amœbæ, but to some occult alteration of the tissues of the host through which the tissues become more resistant to amœbæ. This alteration of the tissues was supposed to be produced by emetine in man, but not in cats.

Dale and Dobell worked exclusively with small kittens, six to eight weeks old, weighing 500 to 600 grams. Emetine failed to cure infected kittens and also failed, prophylactically, to prevent infection when administered before the injection of amœbæ. It was given hypodermically, by rectal injection, and by mouth as the double iodide with bismuth. It is much to be

regretted that the authors recorded but little detail of the actual experiments. The total number of animals in which treatment with emetine was attempted is not stated. Two strains of amœbæ were employed, one of which was exceedingly virulent, the other somewhat less so. One gathers the impression that the major portion of the work was carried out with the more virulent strain. The number of passages through which the strains had been passed before inoculating cats for treatment is not stated, the authors considering that *Entamœba histolytica* does not adapt itself to its new host with any increase of virulence on subpassage.

A detailed description is given of one typical experiment in which one kitten failed to respond to hypodermic injections of emetine. This animal and two controls were successfully inoculated with amœbæ, all of them showing an incubation period of only one day. The two controls died four days after the injection of amœbæ. In testing the effect of emetine, it is very unfortunate that treatment was deferred for one day after the diagnosis was established. The experimental kitten weighed 500 grams and received 5 milligrams of emetine hydrochloride subcutaneously. This produced vomiting and, therefore, 3 milligrams were given on the second and, again, on the third day of treatment. Death occurred on the following (or fourth) day. All three animals at autopsy showed typical ulcers in the large bowel.

Kittens were also treated by the rectal injection of 10 cubic centimeters of emetine hydrochloride in 1 to 10,000 dilution. The authors report that certain samples of *Entamœba histolytica* will withstand the action in vitro of emetine at 1 to 1,000, and even 1 to 100, for one hour, and they infected kittens with amœbæ surviving treatment by 1 to 1,000 emetine. In no case could they detect any microscopic evidence of injury to *Entamœba histolytica* by treatment for one hour with 1 to 10,000 emetine. It can hardly seem surprising, therefore, that a dilution which is without effect in vitro should also fail to produce curative results in vivo.

The failure of emetine to cure kittens infected with the less-virulent strain is recorded, but no experiments are described.

One experiment is described concerning prophylaxis with emetine. Two kittens were given 4 milligrams of emetine bismuthous iodide by mouth. (This compound contains about 30 per cent of emetine.) On the second day, these two kittens and

two controls were injected per rectum with 5 cubic centimeters of an emulsion of the more-virulent strain of amœbæ. The administration of 4 milligrams of emetine bismuthous iodide was repeated by mouth in the two kittens receiving prophylactic treatment. On the first day after the injection of amœbæ, one of the controls and one of the treated kittens were passing blood-stained mucus and amœbæ. The treatments with emetine were omitted on that day. On the second day after injection of amœbæ, the other treated kitten was positive; the remaining control continued negative throughout the experiment. On the second and third days after inoculation, 10 milligrams of the double iodide were given by mouth to the kittens under treatment and then the emetine was discontinued. The infected control died on the fourth day after injection, one of the treated kittens died on the fifth, and the other was killed on the tenth. Typical ulceration was found in all on post-mortem examination.

Mayer(9) produced amœbic dysentery in kittens and tested the therapeutic action of emetine, derivatives of emetine, simaruba, tartar emetic, papaverine, and other substances. No satisfactory results were obtained. Of sixteen cats none was cured with emetine. Emetathylin was efficacious but very toxic.

The observations of Ware(17) in India are of interest. At one of the hill stations, dysentery had given considerable trouble in a pack of foxhounds. Seven animals were affected. Smears from the fæces of the first two hounds that were examined showed amœbæ extremely like *Entamœba histolytica.* All seven were then injected with emetine, and all responded promptly. Dosages of 1 grain were used for large hounds and 0.5 grain for dogs the size of a fox terrier. Only one relapse occurred, although some were obstinate cases of several months' standing. This helpful observation from practice points very directly to the conclusion that emetine was immediately responsible for the recovery of these animals. This conclusion is questioned by Dobell(4) on the ground that the dogs might have recovered without treatment, and because he was not able to cure acute experimental infections in young kittens.

TECHNIC OF EXPERIMENTS

Several strains of amœbæ were inoculated into cats, and the infected animals were treated with various drugs. Attention was directed primarily to emetine, the standard agent for use in man. Quinine and papaverine were also tested, and prelimi-

nary experiments were carried out with benzyl benzoate and *Castela nicholsoni*. Two experiments were carried out on the prophylactic effect of emetine in kittens.

Inoculation.—Kittens are remarkably susceptible to *Entamœba histolytica*, though it is difficult to infect adult cats. In any long series of experiments many irregularities occur. A strain of *Entamœba histolytica*, when passed rapidly through kittens, often assumes fulminating characteristics. In the earlier part of this work we inoculated animals of various sizes with stools obtained direct from patients, in order to secure infections of only moderate severity for treatment. Later on, strains were sometimes carried through several passages in kittens, and from these older animals were inoculated. Specimens of dysenteric stools from patients were injected per rectum, through a small catheter, into animals under general anæsthesia. For subinoculation, the kittens were sacrificed at the height of the infection. The lower third of the large bowel was usually uniformly involved and free from gross fæcal matter. The œdematous and hæmorrhagic mucosa was scraped off with a scalpel and covered with salt solution. These gross particles were rich in amœbæ; without breaking them up unnecessarily, they were injected per rectum, under general anæsthesia, into older cats to be used for treatment and into kittens for maintaining the strain.

Diagnosis.—For the treatment of acute experimental dysentery in cats, the first essential is an early diagnosis. It is useless to delay until spontaneous discharge of blood, mucus, and amœbæ has set in. After a few passages of a strain in animals, the incubation period becomes remarkably short. By employing large saline enemata, amœbæ can often be recovered from the injected animals one or two days before spontaneous symptoms appear, and before extensive destructive lesions of the bowel have developed. Even in the larger cats, a diagnosis was sometimes established forty-eight hours after injection. This does not in any sense suggest that one is merely recovering the amœbæ originally inoculated or that mere multiplication is taking place without the production of lesions. In the first place, some of these larger animals, showing amœbæ on the second day, had been examined and found negative on the first day after injection. Furthermore, we have sacrificed and examined two of these older animals. In one, forty-eight hours after injection, the saline enema which was returned showed a minute fleck of blood containing a few active amœbæ. On the post-mortem examination of the intestine, one hæmorrhagic

area, 3 millimeters in its longest diameter, was found in the lower third of the larger bowel; amœbæ were plentiful in this lesion. In another cat, a diagnosis was obtained three days after injection; post-mortem examination at this time showed one superficial ulcer, 5 millimeters in diameter, in the lower third of the large bowel. In the earlier part of the work little attention was given to specimens that failed to show gross amounts of mucus or blood, and in some of these animals incubation periods as long as five days have been recorded. Subsequently, the specimens were examined carefully for even minute flecks of blood or mucus, and earlier diagnoses were obtained. The routine was eventually established of giving saline enemata daily for diagnosis, commencing the second day after the injection of amœbæ.

Treatment.—A few preliminary trials were made in the treatment of infected cats by the subcutaneous injection of emetine. It was not well tolerated and showed little or no effect on the amœbæ. Subsequently, emetine and the other drugs tested were given in moderately strong solution by rectal injection. On account of the tendency to expel these therapeutic enemata, the animals were always held head downward for a half hour after injection. Examinations for amœbæ were continued daily during the early period of treatment.

Controls.—Spontaneous recovery has been occasionally noted in adult cats; it is of rare occurrence. In this work we have not depended in any sense upon the uncertainties of statistical evidence, but rather upon observation of the immediate radical effect of therapy analogous to the establishment of the therapeutic effect of emetine on amœbic infections in man. From time to time, however, we have arranged for control animals to determine the severity of the various strains of amœbæ used in this work.

Emetine.—Emetine is distinctly toxic for cats. Moreover, repetitions of the effective therapeutic dose are tolerated only for short periods. In our experiments it at once became necessary to establish the maximum limits of the tolerated dosage. This was tested chiefly by injections per rectum. Given in this manner, quantities of 10 milligrams per kilogram of body weight caused no loss of appetite, whereas this amount injected subcutaneously produced nausea and vomiting almost constantly. Moreover, a distinctly better therapeutic effect was obtained by rectal injection as compared with parenteral administration.

The results on normal cats showed that the rectal injection of 10 milligrams per kilogram of body weight for three successive days approaches the danger limit. Except in a few instances, the total quantity of emetine used in treatment has not exceeded 25 milligrams per kilogram of body weight.

Subcutaneous and rectal treatment.—A preliminary test of treatment with emetine was made on an adult cat (No. 1) which developed an acute dysentery after inoculation with a patient's stool. A subcutaneous injection of emetine (8 milligrams per kilogram of body weight), sufficient to cause slight vomiting, produced no discernible effect on the amœbæ. On the second day, 4 milligrams per kilogram were given subcutaneously. On the third day of treatment, rectal injections of emetine were commenced, and three days later the amœbæ disappeared. A little later normal, formed stools were passed. Treatment was discontinued, and the animal remained in apparent health, only to relapse. Treatment was not resumed. Death occurred twenty-seven days after injection of amœbæ. The autopsy showed typical ulceration of the large bowel and two amœbic abscesses of the liver.

There is a twofold difficulty in the treatment of kittens; (*a*) being very susceptible to amœbic infection, they require maximal doses of emetine; and (*b*) the rapid development of lesions in the bowel facilitates greatly the secondary invasion by bacteria. Untreated animals frequently die a few days after inoculation; blood cultures taken during life have showed staphylococci, streptococci, *Bacillus pyocyaneus*, other unidentified bacilli, and in one instance a streptothrix. Early treatment with emetine does not protect against this bacterial invasion. Consequently, the situation arose that kittens frequently became free of amœbæ under vigorous emetine treatment, only to die in a few days, the blood culture showing a septicæmia. Even though this septicæmia is of itself an adequate cause of death, distinct care must be exercised to avoid a dosage of emetine which of itself might prove fatal. Even under these disadvantages, there was frequently sufficient time before death for testing the therapeutic action of emetine.

One animal (No. 2), weighing 870 grams, responded promptly to treatment, the stools being negative for blood and amœbæ after the first day of treatment. Emetine was discontinued three days later, after a total of 35 milligrams per kilogram of body weight had been given. This is a larger quantity than we have usually employed, but it was tolerated without nausea or loss

of appetite. This kitten became very ill eighteen days after injection of amœbæ and was sacrificed. The large intestine showed no microscopic lesions, and no amœbæ were found in smear preparations. A blood culture developed a growth of staphylococcus. A similar result was obtained in the case of kitten 16. Two other kittens (Nos. 10 and 13) behaved in a very similar manner, except that the bacterial complications were more acute, and the animals were sacrificed in little more than a week after injection. No amœbæ were found at autopsy. It is entirely possible that a recrudescence of the amœbic infection might have developed in these animals; but, even if this beneficial result is only temporary, it constitutes a striking contrast to the continuous excretion of amœbæ by the untreated kittens.

The best results were obtained by securing an early diagnosis in adult cats, giving the treatment by rectum. Two adults (Nos. 17 and 18) showed considerable blood and numerous amœbæ on the third day after injection. Emetine in 1 to 1,000 solution was given in a dose of 7.5 milligrams per kilogram to one of these animals and 10 milligrams per kilogram to the other. On the next day, a large normal saline enema was given, but no blood nor amœbæ were obtained from either animal. Treatment was continued until one cat had received a total of 22.5 milligrams of emetine per kilogram of body weight and the other 20. These animals remained well for a long period. One eventually died, thirty-five days after injection. The autopsy did not show any obvious cause of death. The large bowel was entirely free from lesions. The other died eighty-two days after injection. The autopsy showed an extensive bronchopneumonia; the large bowel was free from lesions. These two cats were inoculated from a kitten (No. 20) which developed extensive dysenteric lesions after having received a prophylactic injection of emetine. The virulence of the strain, however, was shown by the acuteness of the initial symptoms in the two treated animals and in an adult control (No. 19), which died six days after inoculation and showed typical amœbic ulceration of the bowel.

The radical cure of amœbic infection in cats is strongly indicated by this experiment. However, adults do not always escape bacterial complications, even though the amœbæ are promptly inhibited by emetine treatment. This was seen in three instances (Nos. 3, 4, and 12).

Inadequate treatment.—In two kittens (Nos. 8 and 9) treatment was discontinued before the maximum tolerated dose had been given. In one (No. 8), after the reappearance of symptoms, a liberal injection of emetine was entirely unavailing; in the other, small doses of emetine were given from the beginning. The symptoms subsided temporarily and then returned while the animal was under treatment.

Delayed treatment.—Some of the animals responded so promptly to emetine that it seemed worth while to try the effect of delaying treatment for a day after the diagnosis was established. In one instance a kitten (No. 7), weighing 800 grams, was passing blood rich in amœbæ four days after inoculation with a patient's stool. On the next day treatment was commenced, giving 10 milligrams of emetine per kilogram of body weight by rectal injection. On the following day frequent bloody stools were passed, rich in actively motile amœbæ. Emetine (10 milligrams per kilogram) was repeated. On the next day the kitten was found dead. Autopsy showed extensive lesions of the bowel, and many amœbæ were still slightly motile.

Effective and tolerated doses.—All of this experimental work has indicated that there is only a small margin between the effective and the tolerated doses of emetine, even under favorable conditions of commencing treatment early in the disease. In adult cats the amœbic infection was sometimes controlled by a dose of about two-thirds the tolerated amount (Nos. 17 and 18). This favorable result, we assume, is due to the natural resistance of adults to *Entamœba histolytica*. In the more-susceptible kittens, the margin between the effective and the tolerated dosage was sometimes very small indeed.

Prophylaxis.—The extreme susceptibility of kittens to *E. histolytica* is strikingly illustrated by their successful infection even when receiving preliminary treatment with emetine. Three kittens, receiving 5 to 10 milligrams of emetine per kilogram of body weight subcutaneously, were inoculated a half hour later with amœbæ. All became infected, the incubation period varying from one to five days. In a second experiment, two kittens were infected after receiving similar doses of emetine per rectum, both showing a decidedly long period of incubation. In these preliminary tests, the use of emetine by rectum gave promise of affording better results than did the subcutaneous

injection. These two experiments do not exhaust the possibilities of preventing dysentery in kittens by the prophylactic use of emetine.

Quinine.—For the most part indifferent or poor results have been reported in the treatment of amœbic dysentery by quinine, although this drug is toxic for cultural amœbæ in vitro and produces very definite effects therapeutically in malaria. A few years ago Brooke(1) reported rather favorable results in the treatment of chronic amœbic infections in man.

Our first test of quinine on animals was made with a cat (No. 27), which for two days had failed to show any response to papaverine. Under large doses of quinine dihydrochloride (200 milligrams per kilogram in 1 to 50 solution) the symptoms improved promptly, and the amœbæ for a short time became very scarce, though it was not possible to eradicate the infection. This temporary improvement under quinine of a well-established infection is in marked contrast to the failure of emetine under similar conditions. A second animal (No. 29) was treated by rectal injection with quinine in 1 to 100 dilution, immediately after the diagnosis was established. On the next day there was little change; another injection of quinine was given (200 milligrams per kilogram of body weight), increasing the concentration to 1 to 50. After a half hour some mucus was expelled which was free from amœbæ. On the next day the stools were negative. Quinine was given once more (200 milligrams per kilogram) and then discontinued. The animal remained in good health for many days, and the stools were formed and negative for blood and amœbæ. Then a relapse occurred. No further treatment was given, and death took place thirty-one days after the inoculation with amœbæ. A third cat (No. 30) was treated more intensively. After an incubation period of three days, this animal was passing blood-streaked mucus rich in amœbæ. Injections of quinine (200 milligrams per kilogram of body weight in 1 to 50 dilution) were commenced at once and continued daily. On the day after the first treatment, the stool showed a trace of tarry blood, and one amœba was found. Thereafter the specimens were negative for blood and amœbæ. On the seventh day of treatment this cat, though strong and active, showed slight muscular tremors and a little nystagmus. Quinine was therefore discontinued. This animal has remained free from symptoms, and no amœbæ have subsequently been found; the last observation was made forty days after inoculation.

Papaverine.—The use of papaverine in protozoan infections has been suggested from time to time, on account of the occurrence of chemical groupings in this alkaloid similar to those in emetine. Pick and Wasicky(10) noted that quinine, emetine, and papaverine were decidedly toxic for cultural amœbæ; emetine, however, was slightly weaker than the other two. Macht and Fisher(8) ascribe the toxic action of papaverine on paramœcia to the benzyl grouping.

Two animals were treated with papaverine by rectal injection in relatively large dosage. Nothing more than a very transient restraining effect on the amœbæ was observed. The first cat received 50 milligrams per kilogram of body weight; on the next day a saline enema was returned which showed one blood clot and many degenerating cells resembling amœbæ; one nonmotile amœba was found. The same dosage of papaverine was repeated. On the following day this cat was passing blood frequently. Numerous active amœbæ were present and treatment with quinine was started. The second cat treated with papaverine received 50 milligrams per kilogram of body weight. On the following day no amœbæ were seen; 75 milligrams of papaverine per kilogram were given. On the next day a few amœbæ were present, and death occurred during the night. At autopsy, typical lesions were found, and sections of the bowel showed definite amœbæ.

Benzyl benzoate.—Macht(7) reported favorable specific action of this drug in several cases of amœbic dysentery. The details of one case were given, but the record is without value. No microscopic examination of the stools was noted either before or after treatment, the opinion being based upon the patient's statement concerning the number of stools. We have had an opportunity to test the action of benzyl benzoate in only one animal. Two days after injection with amœbæ, a saline enema was returned with copious amounts of blood and numerous amœbæ. A suspension of benzyl benzoate (0.5 cubic centimeter per kilogram) in normal saline was injected per rectum. A little was expelled a half hour later and no living amœbæ were found. The next day the cat was passing blood freely, and the amœbæ were very numerous and active. The same dosage was repeated. Death occurred during the night. Although this infection was evidently a rather severe one for treatment, it is significant that benzyl benzoate failed to show any restraining influence.

Castela nicholsoni.—A few preliminary tests were made with *Castela nicholsoni* (chaparro amargoso), but no satisfactory results were obtained. The preparation that was employed is described later in connection with the treatment of dysentery in man. It was extremely toxic for cats, 1 cubic centimeter per kilogram, per rectum, proving fatal. Dosages that showed some therapeutic effect were not tolerated well. If successful results are to be obtained in treating cats with *Castela nicholsoni,* considerable experimentation will be required to determine the most favorable mode of its employment.

The general results of these experiments are summarized briefly in Table 2.

DISCUSSION

In these investigations on the treatment of experimental amœbiasis, quinine was found to possess one distinct advantage over emetine, in that animals would tolerate the continued repetition of effective therapeutic doses. However, it is obviously unsound to draw any final conclusions from limited experience with one or two strains of amœbæ.

From a clinical standpoint it is seen that the amount of quinine necessary to control amœbic infection in cats is very large. One animal (No. 29) eventually relapsed after receiving about 500 milligrams per kilogram of body weight. The minimal effective dose of quinine was not determined. Neither have we tested the effect of quinine administered by mouth or by parenteral injection.

In the treatment of patients with quinine, very dilute solutions (1 to 5,000) are ordinarily recommended, the concentration being increased later to 1 to 1,000 or 1 to 500. We are not aware of any evidence that this preliminary injection of dilute solutions decreases the susceptibility of the bowel for the more-concentrated injections. It is conceivable that the preliminary treatment results chiefly in the loss of time and that, if quinine is to be used, treatment might well be commenced with stronger solutions.

Throughout these experiments we have depended upon the administration of emetine by rectum in rather strong solution. Subcutaneous injection was discontinued on account of the very unfavorable preliminary test. In those special patients in whom emetine by intramuscular injection produces no response, it would seem to us that rectal injection might be worthy of consideration. Obviously, this mode of administration has not met with favor as a routine procedure. Moreover, the simple,

TABLE 2.—*Treatment of experimental amœbic dysentery.*

Cat No.	Weight	Incubation period.	Dosage per kilogram of body weight.	Behavior under treatment.
	g.	*Days.*	*mg.*	
			EMETINE HYDROCHLORIDE.	
1	2,200	6	28	Partial response. Death twenty-seven days after inoculation.
(a)	1,000	3	--------	Death six days after inoculation. Extensive lesions.
(a)	1,450	4	--------	Death seven days after inoculation. Extensive lesions.
2	870	6	35	Negative for amœbæ. Septicæmia. Sacrificed eighteen days after inoculation.
3	1,830	5	30	Partial response. Death (pneumonia) nine days after inoculation.
4	1,500	5	30	Negative for amœbæ. Septicæmia. Sacrificed nine days after inoculation.
5	1,850	5	--------	Control (Nos. 3 and 4) abundant amœbæ. Death six days after inoculation.
6	1,740	6	--------	Control (Nos. 3 and 4) abundant amœbæ. Death nine days after inoculation.
7	800	4	20	Delayed treatment. No response. Death seven days after inoculation.
8	740	4	30	Partial response. Death ten days after inoculation.
9	520	4	15	Partial response. Death (pneumonia) nine days after inoculation.
10	770	4	20	Negative for amœbæ. Septicæmia, no pneumonia. Sacrificed nine days after inoculation.
11	680	5	--------	Control (Nos. 8, 9, 10) abundant amœbæ. Death thirteen days after inoculation.
12	2,400	2	25-30	Negative for amœbæ. Pneumonia. Sacrificed eight days after inoculation.
13	650	3	25	Do.
14	1,820	3	--------	Control (Nos. 12 and 13). Death eighteen days after inoculation. Extensive amœbic ulceration.
15	1,940	4	--------	Control (Nos. 12 and 13). Death seven days after inoculation. Amœbic ulceration of bowel.
16	970	3	22.5	Negative for amœbæ. Septicæmia. Sacrificed eleven days after inoculation.
17	2,520	3	22.5	Negative for amœbæ. Death eighty-two days after inoculation.
18	2,070	3	20	Negative for amœbæ. Death thirty-five days after inoculation.
19	1,700	3	--------	Control (Nos. 16, 17, and 18). Death six days after inoculation.
			PAPAVERINE HYDROCHLORIDE.	
27	1,800	3	100	Amœbæ present. Changed to quinine treatment.
28	1,220	10	125	Amœbæ present. Death thirteen days after inoculation.
			QUININE DIHYDROCHLORIDE.	
29	1,440	10	[b] 500	Negative for amœbæ, then relapsed. Death thirty-one days after inoculation.
30	1,360	3	[b] 1,200	Negative for amœbæ. Remained well.
			BENZYL BENZOATE.	
31	1,570	2	([c])	Amœbæ abundant. Death four days after inoculation.
32	1,680	3	--------	Control. Amœbic ulceration. Death five days after inoculation.

[a] Control. [b] Partial loss. [c] 1 cubic centimeter.

straight, large bowel of the cat permits local treatment more readily than in the case of man.

Occasionally the intravenous injection of emetine is recommended. This route permits the maximal toxic action of emetine on the patient and would seem to us to be the poorest mode of administration. For the treatment of abscess of the liver without operation, the theoretical possibility suggests itself that a very slightly greater concentration of emetine might be obtained in the liver by rectal rather than by intramuscular or intravenous injection, with perhaps a little less of the general toxic manifestation.

The beneficial effect of emetine on amœbic dysentery in cats provides an experimental method for studying the strains of amœbæ from patients who fail to respond to emetine therapy. These patients may, theoretically, be infected with some emetine-resistant strain of amœbæ, or the failures may be due to the vague condition of lowered resistance of the patient. The distinction between these two possibilities has not been approached experimentally; indeed, the solution of the question may lie in some simpler explanation.

COMPARISON OF EMETINE TREATMENT OF AMŒBIC DYSENTERY IN MAN AND IN EXPERIMENTALLY INFECTED ANIMALS

The interpretation of the therapeutic action of emetine in amœbic dysentery in cats necessitates some detailed study. The complete picture requires consideration, not only of the protozoölogical and pharmacological features, but also of the pathology of the experimental disease and its bacteriology, as well as an accurate knowledge of the clinical behavior of patients under treatment. The details of the pathology of the disease appear to us to be worthy of discussion. In young kittens the disease commences in the lowermost portion of the large bowel, producing an intense diffuse inflammation without any trace of normal mucosa in the infected area. In some kittens, sacrificed one day after injection, it appeared that the process begins diffusely, and not as discrete ulcers. In man, in neglected cases coming to autopsy, it is characteristic that large islands of normal mucosa are found in the affected areas. In older cats, the process approximates much more closely the conditions found in man. In two animals, which we have already mentioned, the infection started with a discrete lesion instead of a diffuse generalized inflammation. In cats, as contrasted with kittens, the disease begins less abruptly, runs a slower course,

and there is usually more opportunity for treatment with emetine before a fatal bacterial invasion terminates the experiment.

The clinical behavior of patients under emetine treatment is by no means uniform. Occasionally the symptoms and the amœbæ persist under emetine therapy in cases of only ordinary severity. Shepheard and Lillie(15) studied eighty cases of *Entamœba histolytica* carriers which failed to respond to treatment with emetine bismuthous iodide. Extremely acute infections have been described in which emetine was without value. Although it has not been demonstrated, it seems probable that bacterial invasion might occasionally be an important factor in these acute cases.

Notwithstanding the marked differences between experimental infection and the spontaneous disease, it seems to us that the action of emetine on amœbic dysentery in cats reproduces with very reasonable faithfulness the effects seen in man. Moderately severe infections in adult cats were eradicated by the early and vigorous use of emetine. Inadequate dosage or delay in treatment gave imperfect results or ended fatally, just as we have seen happen altogether too frequently in the practice of medicine in the Tropics. Indeed, it is useless to trifle with minimal dosages of emetine. The absence of any beneficial effect in the treatment of well-established hyperacute experimental infections is closely paralleled by the behavior of fulminating cases in man. Our experimental evidence does not agree with the statement that emetine is specific for *Entamœba histolytica* only in certain special hosts.(5)

The production of dysentery in kittens receiving prophylactic dosages of emetine seems a little surprising at first glance; the conditions, however, are highly artificial. These strains had been well adapted to their new host by several rapid subpassages. Animals at an extremely susceptible age were selected for the test. Moreover, the quantity of the amœbic material injected was enormous, corresponding in Dale and Dobell's work to 600 cubic centimeters for a man of 60 kilograms. Furthermore, actively multiplying tissue-invading forms were injected directly into the rectum, in contrast to the ordinary spontaneous infection with the encysted stage introduced by mouth. In our own work the prophylactic use of emetine per rectum resulted in a marked prolongation of the period of incubation. Curiously enough, this partial failure in the prophylactic action of emetine is offset in a measure by the beneficial

action which it exhibited in several instances when administered therapeutically to infected kittens.

These experiments furnish no direct evidence concerning the mechanism of the action of emetine in amœbic dysentery. In the recovery of patients, we must consider both the resistance of the host to amœbæ and the effect of emetine. Clinical evidence is very convincing that the normal individual exhibits considerable natural resistance to *Entamœba histolytica,* leading ordinarily to spontaneous remission of symptoms even in untreated patients. Emetine is not only moderately toxic for amœbæ in vitro, but is also distinctly toxic for mammals. It does not seem likely to us that *E. histolytica* in its host can entirely escape this toxic action. The maximal therapeutic doses of emetine are relatively small, but they are cumulative in their effect. Until there is experimental evidence to the contrary, we prefer to adhere to the following working basis: That recovery from amœbic dysentery in man and in lower animals results from the combined action of the natural resistance of the host and a moderate action of emetine on the amœbæ. The summation of these two factors is necessary for radical cure. A lowering of either allows the disease to progress. Minimal doses of emetine do not modify the course of the infection. The effect of feeble natural resistance of the host is beautifully illustrated by the fulminating infections seen in young kittens.

A comparison of the effective dosage of emetine in man and in experimental animals is difficult, on account of the severity of the artificial infection. Moreover, patients are treated by small doses over a period of many days or weeks, whereas the animals must be treated intensively for a short period. The following outline (Table 3) shows the relation between the ordinary therapeutic dose used in man and the quantities that we have employed. These have been arranged to show both the initial dose required to check the symptoms and the total quantity for eradicating an infection. The latter is extremely variable in man, and the figures given represent optimal results.

TABLE 3.—*Showing the amounts of emetine hydrochloride used in the treatment of amœbic dysentery in man and in cats; milligrams per kilogram of body weight.*

	In man.	In cats.
	mg.	*mg.*
Initial dose	2-4	7-10
Total quantity	18-30	20-30

These figures are of only general interest. In the first place, emetine hydrochloride was given to the infected animals by injection per rectum, whereas this alkaloid is usually given intramuscularly in man. The figures for patients are based, for convenience, on an average body weight of 60 kilograms. The initial dose in man of 2 milligrams per kilogram (that is, 2 grains) on the first day of treatment is slightly larger than the routine usually recommended. However, it is the quantity that we ordinarily employ; but, even with this amount, the symptoms are not checked as promptly as with the 10-milligram dose used in animals. The maximal initial dose in man, 4 milligrams per kilogram, represents the dosage occasionally used by Rogers(13) in severe cases; that is, 4 grains on the first day of treatment. It has not come into general use, even in especially severe cases. The figure of 18 milligrams per kilogram for the total quantity in man for the first course of treatment is taken from Wenyon and O'Connor's(18) recommendation of 1.5 grains of emetine hydrochloride for twelve consecutive days.

SUMMARY

1. The treatment of amœbic dysentery in kittens is seriously complicated by the acuteness of the amœbic process and by the secondary bacterial invasion. The disease in young kittens is not strictly comparable to amœbic dysentery in man, on account of the differences in pathology of the two conditions.

2. Suitable conditions for experimental therapy can be secured by infecting adult cats with a moderately virulent strain of *Entamœba histolytica*. In order to secure successful results an early diagnosis is imperative, and vigorous treatment must be instituted without delay.

3. Infections with *E. histolytica* were produced in cats and treated successfully with emetine and with quinine. Papaverine was inefficacious. Emetine and papaverine have certain active chemical groupings in common; namely, the four methoxy radicals. Quinine has one methoxy radical; its general structure is unlike papaverine and, presumably, unlike emetine.

4. In the treatment of cats with quinine very large doses were required; but, in contrast to emetine, repetitions of the therapeutic dose could be tolerated for many days.

5. Experimental amœbic dysentery is a somewhat artificial condition; nevertheless, it responds to emetine in a manner similar to the action of emetine in spontaneous dysentery in man.

ABSTRACT OF EXPERIMENTS

The accompanying notes give brief abstracts of the more-important experiments. Many unfavorable results have been included to illustrate the conditions essential for success. The drugs used for treatment have always been given by rectal injection, except where otherwise noted. The enemata that are recorded refer exclusively to saline injections given for the purpose of diagnosis. The microscopic examination of stools refers only to perfectly fresh specimens that were passed while the animals were under observation in the laboratory. Negative examinations for amœbæ are not recorded in the autopsy of animals that were found dead; such reports might be misleading, on account of the rapid degeneration of amœbæ after death of the host. No blood cultures were made on animals that were found dead.

TREATMENT WITH EMETINE

Toxicity.—Emetine hydrochloride was used in 1 to 1,000 dilution in water. The following tests were made to determine its toxicity. Six adult cats weighing 1,800 to 2,400 grams were given daily doses of 10 milligrams per kilogram for three successive days. The injections were made subcutaneously in two, and by rectum in the other four, the animals being observed for two to three hours after injection to be sure that no loss took place during this period. On the fourth day both of the cats receiving subcutaneous injection were found dead. Of the animals receiving injections per rectum, one was nauseated on the fourth day and died during the night; the other three remained well.

STRAIN I; FIRST PASSAGE; CAT 1

October 28, 1920. Weight, 2,200 grams; injected with amœbæ direct from patient.

November 3. Weight, 2,100 grams; enema, copious amount of blood and numerous amœbæ; incubation period six days; injected subcutaneously with 8 milligrams of emetine per kilogram; slight vomiting; during the day three bloody stools rich in amœbæ were passed.

November 4. Weight, 2,000 grams; enema, blood and active *E. hystolytica;* emetine, 4 milligrams per kilogram injected subcutaneously.

November 5. Weight, 2,000 grams; passing blood rich in amœbæ not actively phagocytic; emetine, 8 milligrams per kilogram per rectum.

November 6. Weight, 1,940 grams; yellow fæcal stool rich in amœbæ; emetine, 4 milligrams per kilogram per rectum.

November 7. No examination.

November 8. Weight, 1,790 grams; semiformed stool slightly blood-streaked; no amœbæ; enema, no blood nor amœbæ; emetine, 4 milligrams per kilogram per rectum.

November 9. No stools.

November 11. Enema, negative.

November 12. Nauseated, refuses food; suppression of urine; 200 cubic centimeters of normal saline injected intraperitoneally.

November 12. Weight, 1,900 grams; appetite good; voids freely; enema, negative.

November 18. Weight, 1,950 grams; formed stool shows no blood nor amœbæ.

November 20. Weight, 1,850 grams; freshly passed stool is negative.

November 24. Found dead; several active ulcers in the intestine and two amœbic abscesses in the liver; total emetine, 28 milligrams per kilogram within five days.

Of two control animals one, weighing 1,000 grams, showed an incubation period of three days and died on the sixth day after injection of amœbæ; the other, weighing 1,450 grams, had an incubation period of four days and died three days later.

In the next experiment one kitten and five adult cats were injected with a patient's stool, rich in blood and mucus and containing numerous active amœbæ. None of the adults became infected.

STRAIN II; FIRST PASSAGE; CAT 2

August 31, 1921. Weight, 870 grams; inoculated direct from patient.

September 6. Enema, abundant blood, mucus, and amœbæ; incubation period six days; emetine, 10 cubic centimeters per kilogram; an hour later a small bloody specimen was passed showing a few motile amœbæ and many degenerated forms.

September 7. Weight, 820 grams; enema, no blood, mucus, nor amœbæ; emetine, 10 milligrams per kilogram; two hours later a fæcal stool was passed; microscopically red blood cells were seen but no amœbæ.

September 8. Weight, 870 grams; two soft fæcal stools in cage; enema, negative; emetine, 5 milligrams per kilogram intramuscularly.

September 9. Emetine, 10 milligrams per kilogram.

September 10. Weight, 850 grams; enema, formed stool, negative; emetine discontinued.

September 12. Fresh stool is negative.

September 13. Weight, 770 grams; no stools passed.

September 15. Soft fæcal stool negative for amœbæ.

September 18. Weight, 620 grams; extensive infection about the eyes; very ill; sacrificed; large bowel shows no blood nor mucus; the mucosa shows no scars of healed lesions and microscopically no amœbæ; a culture from the heart blood showed a growth of staphylococcus; total emetine, 35 milligrams per kilogram within three days.

In the following experiment, four adult cats (Nos. 3, 4, 5, and 6) were injected with amœbæ; two were treated, bacterial complications developing very early, and two were reserved for controls.

STRAIN III; FIRST PASSAGE; CAT 3

September 28, 1921. Weight, 1,830 grams; injected direct from patient.

October 3. Enema, copious amount of blood rich in amœbæ; incubation period, five days; emetine, 10 milligrams per kilogram.

October 4. Weight, 1,800 grams; stool of tarry consistency; no fresh blood and no amœbæ; emetine, 10 milligrams per kilogram.

October 5. Weight, 1,720 grams; tarry stool shows no amœbæ; emetine, 10 milligrams per kilogram.

October 6. Enema, some blood and after long search one amœba was found.

October 7. Found dead; broncho-pneumonia; no inflammation nor ulceration of the large bowel; total emetine, 30 milligrams per kilogram within two days.

STRAIN III; FIRST PASSAGE; CAT 4

September 28, 1921. Weight, 1,500 grams; injected direct from patient.

October 3. Enema, fresh blood showing many active amœbæ; incubation period, five days; emetine, 10 milligrams per kilogram.

October 4. Soft fæcal stool, no amœbæ; enema, no blood nor amœbæ; emetine, 10 milligrams per kilogram.

October 5. Weight, 1,400 grams; emetine, 10 milligrams per kilogram.

October 6. Enema, no blood nor amœbæ.

October 7. Very ill; sacrificed; no pneumonia; one ulcer, 7 millimeters in diameter, in lower third of large bowel; no amœbæ found; blood culture showed a staphylococcus; total emetine, 30 milligrams per kilogram within two days.

STRAIN III; FIRST PASSAGE; CAT 5

Control for Nos. 3 and 4.

September 28, 1921. Weight, 1,850 grams; injected with amœbæ.

October 3. Positive for amœbæ; incubation period, five days.

October 4. Dead; typical ulceration of intestine.

STRAIN III; FIRST PASSAGE; CAT 6

Control for Nos. 3 and 4.

September 28, 1921. Weight, 1,740 grams; injected with amœbæ.

October 4. Passing mucus containing a few amœbæ; incubation period, six days.

October 7. Dead; typical ulceration of intestine.

STRAIN III; FIRST PASSAGE; CAT 7

Delayed treatment.

September 11, 1921. Weight, 800 grams; injected with amœbæ.

September 15. Passing blood rich in amœbæ; incubation period, four days; no treatment.

September 16. Bloody stools rich in amœbæ; emetine, 10 milligrams per kilogram; forty-five minutes later a stool was passed containing many degenerating amœbæ.

September 17. Frequent bloody stools, numerous active amœbæ; emetine, 10 milligrams per kilogram.

September 18. Found dead; extensive typical lesions of the lower third of the large bowel; amœbæ still motile; total emetine, 20 milligrams per kilogram within one day.

In the next experiment, four kittens were inoculated. All became infected and three were treated.

STRAIN IV; FIRST PASSAGE; CAT 8

September 24, 1921. Weight, 740 grams; injected direct from patient.

September 28. Enema, considerable blood and many amœbæ; incubation period, four days; emetine, 10 milligrams per kilogram; after ten minutes a few drops of fluid were expelled; this was rich in motile amœbæ, but they became rounded up and many degenerated while under observation during the next fifteen minutes.

September 29. Weight, 720 grams; passing blood containing amœbæ; emetine, 10 milligrams per kilogram.

September 30. Weight, 750 grams; formed stool, negative; enema, negative; no treatment.

October 1. Enema, negative.

October 3. Passing a little blood rich in amœbæ; emetine, 10 milligrams per kilogram.

October 4. Dead; intense inflammation of the lower portion of the large bowel; total emetine, 30 milligrams per kilogram within five days.

STRAIN IV; FIRST PASSAGE; CAT 9

September 24, 1921. Weight, 520 grams; injected direct from patient.

September 28. Enema, copious amount of blood and many amœbæ; incubation period, four days; emetine, 5 milligrams per kilogram.

September 29. Soft yellow stool showed no amœbæ and no gross blood; emetine, 5 milligrams per kilogram.

September 30. On starting to introduce the rectal tube, a well-formed stool was passed; no blood nor amœbæ; enema was returned with one small fleck of blood containing a few amœbæ; emetine, 5 milligrams per kilogram.

October 1. Enema, blood and amœbæ.

October 2. Enema, blood and amœbæ.

October 3. Found dead; extensive broncho-pneumonia on the left side; slight inflammation and a few minute ulcers in the lower portions of the bowel; total emetine, 15 milligrams per kilogram within two days.

STRAIN IV; FIRST PASSAGE; CAT 10

September 24, 1921. Weight, 770 grams; inoculated direct from patient.

September 28. Enema, abundant blood, mucus, and amœbæ; incubation period, four days; emetine, 10 milligrams per kilogram.

September 29. Soft fæcal stool, negative for blood and amœbæ; emetine, 5 milligrams per kilogram.

September 30. Weight, 720 grams; enema, negative; emetine, 5 milligrams per kilogram.

October 1. Enema, negative.

October 3. Sacrificed; no pneumonia; some pus in large bowel but no amœbæ found; blood culture gave a growth of streptococcus; total emetine, 20 milligrams per kilogram within two days.

STRAIN IV; FIRST PASSAGE; CAT 11

Control for Nos. 8, 9, and 10.

September 24, 1921. Weight, 680 grams; injected with amœbæ.

September 29. Abundant blood and amœbæ; incubation period, five days.

October 7. Dead; no pneumonia; extensive lesions throughout the large bowel; amœbæ present but not motile.

Of seven animals inoculated with Strain V in the second passage, four became infected (Nos. 12 to 15).

STRAIN V; SECOND PASSAGE; CAT 12

November 13, 1921. Weight, 2,400 grams; injected with amœbæ.

November 15. Enema, trace of blood and several active amœbæ; incubation period, two days; emetine, 10 milligrams per kilogram.

November 16. Weight, 2,350 grams; enema, no gross blood; microscopically, a few red cells, no amœbæ; emetine, 10 milligrams per kilogram.

November 17. Weight, 2,320 grams; tarry stool; no amœbæ; emetine, 5 milligrams per kilogram, expelled almost immediately; 2.5 milligrams per kilogram repeated subcutaneously.

November 18. Weight, 2,250 grams; enema, negative; emetine, 5 milligrams per kilogram returned at once.

November 19. Weight, 2,270 grams; enema, negative.

November 20. Weight, 2,150 grams; enema, negative.

November 21. Ill; sacrificed; extensive broncho-penumonia on right side; no inflammation of bowel, no amœbæ found; total emetine, probably 25 to 30 milligrams per kilogram within three days.

STRAIN V; SECOND PASSAGE; CAT 13

November 13, 1921. Weight, 650 grams; injected with amœbæ.

November 15. Enema, negative.

November 16. Enema, abundant mucus and many active amœbæ; incubation period, three days; emetine, 10 milligrams per kilogram; considerable loss after fifteen minutes; 2.5 milligrams per kilogram repeated subcutaneously.

November 17. Enema, negative; emetine, 2.5 milligrams per kilogram subcutaneously.

November 18. Weight, 570 grams; small bloody stool rich in amœbæ; emetine, 5 milligrams per kilogram; retained.

November 19. Enema, negative; emetine, 5 milligrams per kilogram.

November 20. Enema, negative.

November 21. Ill; sacrificed; extensive bilateral broncho-pneumonia; some hyperæmia of the lower portion of the large bowel; no amœbæ found; total emetine, not over 25 milligrams per kilogram.

STRAIN V; SECOND PASSAGE; CAT 14

Control for Nos. 12 and 13.

November 13, 1921. Weight, 1,820 grams; injected with amœbæ.

November 16. Passed abundant mucus; one amœba found.

November 21. No stools.

November 22. Passing copious amounts of blood and mucus rich in amœbæ.

December 1. Dead; weight, 1,540 grams; had been passing blood and mucus continuously; extreme ulcerations throughout entire large bowel.

STRAIN V; SECOND PASSAGE; CAT 15

Control for Nos. 12 and 13.

November 13, 1921. Weight, 1,940 grams; injected with amœbæ.

November 15. Enema, blood clots but no amœbæ.

November 16. Enema, mucus but no amœbæ.

November 17. Enema; trace of blood and several active amœbæ; incubation period, four days.

November 18. No stools.

November 19. Soft fæcal stool containing a few amœbæ.

November 20. Dead; inflammation in lower bowel with two distinct ulcers.

Six adult cats and one kitten were inoculated for the fifth passage of this strain. Three of the cats remained well.

STRAIN V; FIFTH PASSAGE; CAT 16

December 1, 1921. Weight, 970 grams; injected with amœbæ.

December 4. Enema, mucus, blood, and numerous amœbæ; incubation period, three days; emetine, 7.5 milligrams per kilogram.

December 5. Weight, 920 grams; mucous stool; one minute area in the cover-glass preparation shows numerous active amœbæ; two additional preparations showed no amœbæ; emetine, 7.5 milligrams per kilogram; slight loss after a half hour.

December 6. Enema, negative; emetine, 7.5 milligrams per kilogram.

December 7. Weight, 900 grams; firmly formed stool; no blood nor amœbæ.

December 8. Enema, no blood nor amœbæ.

December 10. Enema, negative.

December 12. Dying; septicæmia; total emetine, not over 22.5 milligrams per kilogram within two days.

STRAIN V; FIFTH PASSAGE; CAT 17

December 1, 1921. Weight, 2,520 grams; injected with amœbæ.

December 4. Enema, moderate amount of blood and numerous amœbæ; emetine, 7.5 milligrams per kilogram.

December 5. Weight, 2,500 grams; enema, mucus; no blood nor amœbæ seen; emetine, 7.5 milligrams per kilogram.

December 6. Weight, 2,520 grams; enema, negative; emetine, 7.5 milligrams per kilogram.

December 7. Weight, 2,500 grams.

December 8. Weight, 2,520 grams; enema, negative.

December 9. Weight, 2,450 grams; enema, negative.

December 15. Enema, firmly formed fæces; no blood nor amœbæ.

January 16, 1922. In good condition; enema, negative.

February 21. Found dead; bilateral broncho-pneumonia; no lesions in large intestine; total emetine, 22.5 milligrams per kilogram within two days.

STRAIN V; FIFTH PASSAGE; CAT 18

December 1, 1921. Weight, 2,070 grams; injected with amœbæ.

December 4. Enema, abundant blood and numerous amœbæ; incubation period, three days; emetine, 10 milligrams per kilogram; slight bloody discharge after fifteen minutes; practically all of the amœbæ are rounded up, and some are disintegrating.

December 5. Enema, negative; emetine, 10 milligrams per kilogram.

December 7. Negative.

December 12. Enema, firmly formed stool, negative.

December 18. Formed stool, negative.

January 4, 1922. Found dead; lungs normal; no lesions in bowel; total emetine, 20 milligrams per kilogram within one day.

STRAIN V; FIFTH PASSAGE; CAT 19

Control for Nos. 16, 17, and 18.
December 1, 1921. Weight, 1,700 grams.
December 3. Enema, some mucus, no amœbæ.
December 4. Enema, blood with active amœbæ.
December 5. No stool.
December 6. Enema, blood and numerous amœbæ.
December 7. Dead; deep ulceration of lower portion of large bowel.

PROPHYLACTIC TESTS WITH EMETINE SUBCUTANEOUSLY

STRAIN V; FOURTH PASSAGE; CAT 20

November 26, 1921. Weight, 670 grams; emetine, 10 milligrams per kilogram subcutaneously; one-half hour later, amœbæ injected.

November 27. Formed stool; refuses milk; no emetine given.

November 28. Weight, 570 grams; enema, one small clot of blood, numerous active amœbæ; incubation period, two days; emetine, 5 milligrams per kilogram subcutaneously.

November 29. Weight, 520 grams; enema, active amœbæ and blood; emetine (rectally), 5 milligrams per kilogram.

November 30. Passing mucus and fair number of amœbæ; emetine (rectally), 5 milligrams per kilogram.

December 1. Sacrificed; extensive lesions of lower part of gut; active amœbæ; total emetine, 25 milligrams per kilogram within four days.

STRAIN V; FOURTH PASSAGE; CAT 21

November 26, 1921. Weight, 620 grams; emetine, 5 milligrams per kilogram, subcutaneously; a half hour later, amœbæ injected.

November 27. Enema, mucus and an occasional amœba; incubation period, one day. Emetine, 5 milligrams per kilogram, subcutaneously; vomited.

November 28. Small blood-tinged stool, amœbæ numerous; emetine, 5 milligrams per kilogram, subcutaneously.

November 29. Blood-tinged stools, active amœbæ; emetine, 5 milligrams per kilogram (rectally).

November 30. Dead; extensive pneumonia on left side; slight superficial inflammation of lowermost part of bowel; total emetine, 20 milligrams per kilogram within three days.

STRAIN V; FOURTH PASSAGE; CAT 22

November 26, 1921. Weight, 570 grams; emetine, 5 milligrams per kilogram, subcutaneously; a half hour later, amœbæ injected.

November 27. Enema, negative; emetine, 5 milligrams per kilogram, subcutaneously; vomited.

November 28. Fæcal stool; enema, negative; emetine, 5 milligrams per kilogram, subcutaneously; drank milk freely.

November 29. Enema, negative.

December 1. Enema, a little mucus; one amœba found; incubation period, five days; very ill; chloroformed; lungs normal; rectum, moderate superficial inflammation; heart-blood culture, *Bacillus pyocyaneus;* total emetine, 15 milligrams per kilogram within two days.

STRAIN V; FOURTH PASSAGE; CAT 23

Control for Nos. 20, 21, and 22.

November 26, 1921. Weight, 510 grams; amœbæ injected.

November 27. Two soft mucous stools; no amœbæ.

November 28. Blood-tinged stool; one motile amœba found in fifteen minutes' search; incubation period, two days.

November 29. Passing blood freely with many amœbæ.

December 1. Very ill; sacrificed; inflammation of rectum with one large ulcer; blood culture, coarse gram-positive bacillus; one other control for this series died the second day after injection of amœbæ; no lesions of bowel.

PROPHYLACTIC TESTS WITH EMETINE PER RECTUM

STRAIN VI; FIRST PASSAGE; CAT 24

December 4, 1921. Weight, 520 grams; emetine, 10 milligrams per kilogram; a half hour later, amœbæ injected.

December 5. Emetine, 5 milligrams per kilogram.

December 6. Enema, negative.

December 8. Enema, negative.

December 10. Enema, negative.

December 12. Enema, blood and amœbæ; incubation period, eight days.

December 13. Sacrificed; extensive inflammation of lower third of large bowel; active amœbæ; blood culture developed a staphylococcus; total emetine, 15 milligrams per kilogram within one day.

STRAIN VI; FIRST PASSAGE; CAT 25

December 4, 1921. Weight, 650 grams; emetine, 5 milligrams per kilogram; a half hour later, amœbæ injected.

December 5. Emetine, 5 milligrams per kilogram.

December 8. Enema, negative.

December 13. Enema, negative.

December 17. Enema, negative.

December 19. Found dead; typical inflammation in lower part of bowel; total emetine, 15 milligrams per kilogram within two days.

STRAIN VI; FIRST PASSAGE; CAT 26

Control for Nos. 24 and 25.

December 4, 1921. Weight, 700 grams; injected amœbæ.

December 7. Enema, abundant blood and amœbæ; incubation period, three days.

December 12. Dead; typical lesions; two older cats weighing 1,650 and 1,700 grams were inoculated as additional controls for this series, but they failed to become infected.

TREATMENT WITH PAPAVERINE AND QUININE

Tests for toxicity.—The fatal dose of papaverine for cats is usually stated to be 100 milligrams per kilogram of body weight injected subcutaneously. Two adult cats were injected per rectum with papaverine hydrochloride in 2 per cent solution, using 50 milligrams per kilogram. On the second day this dosage was repeated in one animal; the other was given 75 milligrams per kilogram. Both became extremely drowsy, but recovered.

The lethal dose of quinine for cats was not determined, but in one animal under treatment the quantity was pushed until toxic symptoms developed. The dihydrochloride was used as a routine in 2 per cent solution. After giving the therapeutic enemata the animals were held as usual with the head downward for a half hour, but on returning them to their cages, a stool was always passed promptly. Therefore, the dosages recorded in the protocols represent merely the amounts injected, the quantity absorbed being necessarily smaller than the recorded figures.

STRAIN VII; THIRD PASSAGE; CAT 27

March 18, 1922. Weight, 1,800 grams; injected with amœbæ.

March 21. Enema, trace of blood and a few typical entamœbæ; incubation period, three days; papaverine hydrochloride, 2 per cent solution, 50 milligrams per kilogram.

March 22. Weight, 1,700 grams; fæcal stool in cage; enema, fæcal matter and one small blood clot; many degenerated cells resembling amœbæ; one nonmotile amœba seen; papaverine, 50 milligrams per kilogram.

March 23. Weight, 1,720 grams; passing blood and numerous amœbæ; quinine dihydrochloride, 2 per cent solution, 200 milligrams per kilogram.

March 24. Enema, no blood nor mucus, one amœba found; quinine, 200 milligrams per kilogram, almost completely expelled; repeated in the afternoon.

March 25. Enema, negative for blood and amœbæ; quinine, 100 milligrams per kilogram.

March 26. Weight, 1,650 grams; enema, blood and mucus and numerous active amœbæ; quinine, 200 milligrams per kilogram.

March 27. Weight, 1,650 grams; enema, negative; quinine, 200 milligrams per kilogram.

March 28. Enema, negative for blood and amœbæ; quinine, 100 milligrams per kilogram.

March 29. Weight, 1,730 grams; enema, negative; no treatment; passed formed stool.

March 30. Weight, 1,700 grams; enema, no blood, a few amœbæ; quinine, 200 milligrams per kilogram.

March 31. Enema, negative.

April 1. Weight, 1,600 grams; passed mucus and amœbæ; quinine, 200 milligrams per kilogram.

April 2. Quinine, 200 milligrams per kilogram.

April 3. Enema, a little mucus; several amœbæ; quinine, 200 milligrams per kilogram.

April 4. Enema, a little mucus and, after twenty minutes' search, one amœba; quinine, 200 milligrams per kilogram.

April 5. Enema, formed stool negative for blood and amœbæ; immediately second enema, blood and mucus and many amœbæ; quinine, 200 milligrams per kilogram.

April 6. Weight, 1,570 grams; enema, numerous amœbæ; sacrificed; extensive deep ulcerations widely distributed throughout the large bowel;

total papaverine, 100 milligrams per kilogram within one day; total quinine, not over 2,200 milligrams per kilogram within fourteen days.

STRAIN VII; THIRD PASSAGE; CAT 28

March 18, 1921. Weight, 1,220 grams; injected with amœbæ.

March 28. Enema, no blood; mucus and a few amœbæ; incubation period, ten days; papaverine, 50 milligrams per kilogram.

March 29. Enema, a little mucus, no blood nor amœbæ; papaverine, 75 milligrams per kilogram.

March 30. Very drowsy; enema, some blood and a few amœbæ; no treatment.

March 31. Dead; lower portion of rectum is filled with blood and the mucosa shows extensive lesions; sections show amœbæ; total papaverine, 125 milligrams per kilogram within one day.

STRAIN VII; THIRD PASSAGE; CAT 29

March 18, 1921. Weight, 1,440 grams; injected with amœbæ.

March 28. Enema, formed stool, some mucus and several amœbæ; incubation period, ten days; quinine (1 per cent), 100 milligrams per kilogram.

March 29. Formed stool in cage; enema, trace of blood and many amœbæ; quinine (2 per cent), 200 milligrams per kilogram.

March 30. Enema, formed stool; no blood nor amœbæ; quinine, 200 milligrams per kilogram.

March 31 to April 13. Formed stools; enema, no blood nor amœbæ.

April 18. Dead; autopsy, lower portion of large bowel contains formed stool; bowel wall is ulcerated and œdematous: smears show definite amœbæ; total quinine, not over 500 milligrams per kilogram within two days.

STRAIN VIII; THIRD PASSAGE; CAT 30

June 5, 1921. Weight, 1,360 grams; injected with amœbæ.

June 7. Enema, negative.

June 8. Passing blood-streaked mucus rich in amœbæ; incubation period, three days; quinine, 200 milligrams per kilogram, in 2 per cent solution.

June 9. Enema, trace of old blood, one amœba; quinine, 200 milligrams per kilogram.

June 10. Enema, some tarry blood, no amœbæ; quinine, 200 milligrams per kilogram.

June 11. Weight, 1,320 grams; enema, negative; quinine, 200 milligrams per kilogram.

June 12. Enema, negative; quinine, 200 milligrams per kilogram.

June 13. Quinine, 200 milligrams per kilogram.

June 14. Weight, 1,280 grams; active and strong, but shows slight muscular tremors and a little nystagmus; treatment discontinued.

June 17. Enema, negative.

June 22. Weight, 1,200 grams; enema, negative.

June 28. Enema, negative.

July 3. Weight, 1,150 grams; enema, negative.

July 15. Weight, 1,150 grams; formed stool; enema, negative; observations discontinued; total quinine, not over 1,200 milligrams per kilogram.

TREATMENT WITH BENZYL BENZOATE

The toxicity of benzyl benzoate proved to be much greater than we had expected. An adult cat injected per rectum with

1.5 cubic centimeters per kilogram, in suspension in normal saline, died within twenty-four hours. A second cat, injected with 0.5 cubic centimeter per kilogram on two successive days, remained well.

STRAIN VIII; FOURTH PASSAGE; CAT 31

June 13, 1921. Weight, 1,570 grams; injected with amœbæ.

June 15. Enema, blood and numerous amœbæ; incubation period, two days; benzyl benzoate, 0.5 cubic centimeter per kilogram; a few drops were expelled containing numerous dead amœbæ.

June 16. Passing fresh blood freely, amœbæ numerous and active; benzyl benzoate, 0.5 cubic centimeter per kilogram.

June 17. Dead; extensive typical lesions of large bowel.

STRAIN VII; FOURTH PASSAGE; CAT 32

Control for Strain VIII.

June 13, 1921. Weight, 1,680 grams; injected with amœbæ.

June 16. Enema, mucus and a few red cells and amœbæ; incubation period, three days.

June 18. Dead; three deep ulcers in large bowel.

III. CLINICAL OBSERVATIONS

Several plants belonging to the family Simarubaceæ are very popular among the peoples native to the Tropics as remedies for the treatment of dysentery; considerable evidence has accumulated indicating their favorable action in amœbic infections. Two of the best known are *Brucea amarissima* (Loureiro) Merrill (*B. sumatrana* Roxburgh), from which is derived the *kho-sam* powder of China, and *Castela nicholsoni* Hooker, or chaparro amargoso, of Mexico. These plants possess an intensely bitter toxic principle, but it has not been identified nor even isolated in sufficient quantity for use in clinical work. Favorable results have been obtained in amœbic dysentery with *C. nicholsoni,* even in cases which failed to respond to emetine. In the work here set forth we have compared the action of *C. nicholsoni* of central America with other members of the Simarubaceæ occurring in the Philippines, with the object of determining whether some of the local species could be used to advantage in place of emetine. In addition to *Castela nicholsoni* two species of other genera were available for study; namely, *Harrisonia perforata* (Blanco) Merrill and *Brucea amarissima* (Loureiro) Merrill. Few of the poorer Filipinos, even though they live in Manila, ever receive adequate and thorough treatment with emetine under satisfactory laboratory control. Simplification of the treatment is urgently needed.

Treatment of dysentery with extracts of the Simarubaceæ has always suffered from the disadvantage that no standardization of dosage has been attempted. In the complete absence of

any guiding information concerning the rather feeble commercial preparations, it is probable that quantities have been used which fall considerably short of both the tolerated and the effective doses. In our work we have prepared some concentrated and highly toxic extracts of two of these plants. No attempt has been made to determine chemically the content of the active principle. The fatal dose for rabbits was estimated in order to secure a general guide for commencing the administration in man.

Method of preparation.—The bitter principle of these plants is soluble in either alcohol or water. Elimination of the greater portions of the gums, resins, chlorophyll, and starch can be readily effected by extracting first with alcohol, evaporating almost to dryness, and then extracting the residue with water. For *Castela nicholsoni* the smaller twigs were ground to a fine powder. The bitter principle of this was extracted by boiling for several hours with methyl alcohol, in the proportion of 1 kilogram of the powder to 5 liters of alcohol. One extraction removed the bitter principle almost completely. After filtration the alcohol was evaporated at low temperature, and a tarry residue was left behind. A quantity of residue representing 12 kilograms of the powdered plant was extracted with 200 cubic centimeters of water divided into small portions. This extract was found to be very toxic for rabbits, 0.1 cubic centimeter injected subcutaneously producing death overnight. For convenience, this quantity of 200 cubic centimeters was diluted to 1 liter. Injected subcutaneously, 1 cubic centimeter of this solution per kilogram killed rabbits within twenty-four hours; 0.5 cubic centimeter produced no symptoms.

The extracts of *Harrisonia perforata* and *Brucea amarissima* were very kindly prepared by Dr. H. I. Cole, of the division of organic chemistry of the Bureau of Science. The extraction of these two drugs was carried out more thoroughly than was done in the case of *Castela;* the toxicity of these extracts represents, roughly but not accurately, the relative toxicity of the corresponding plants. Ethyl alcohol was substituted for methyl. The *Harrisonia perforata* material was shade dried, and the branches and leaves were ground to a coarse powder. Only the seeds of *Brucea amarissima* were used. A rather dilute preparation of *Harrisonia* was employed, of which 2 cubic centimeters represented 1 gram of the original plant. Rabbits were killed in from twenty-four to forty-eight hours by the subcutaneous injection of 15 cubic centimeters of this solution, but

not by 10 cubic centimeters. A more-concentrated solution of *Brucea* was employed. One cubic centimeter represented 4 grams of the original seeds, and subcutaneous injection of rabbits with this amount resulted fatally in from twelve to twenty-four hours; 0.5 cubic centimeter was without any apparent effect.

Clinical results.—All of the patients studied were cases of frank amœbic dysentery, seen either in the first attack or during a typical recidive. Five patients were treated with *Castela nicholsoni*, two with *Brucea amarissima*, and two with *Harrisonia perforata*. Preparations of these plants were always given by mouth, except in one instance, where a few doses were given by injection per rectum. Prompt relief of symptoms, accompanied by the disappearance of amœbæ from the stools, was obtained only with *Castela nicholsoni*. With each of the others, some clinical improvement occurred for a few days, but in three of the four cases the amœbæ persisted and the symptoms returned while the patients were under treatment. In four of the cases treated with *Castela* we have been able to secure an examination of the patient after an interval of several months. One patient relapsed; three remained entirely free of symptoms, although one was passing cysts of *Entamœba histolytica*. The last case illustrates well that freedom from clinical symptoms does not constitute a biological test for the eradication of entamœbæ. However, we would not belittle the value of a drug which affords prolonged clinical relief.

SUMMARY

1. Three species, representing three genera of the Simarubaceæ, were tested for their efficacy in treating amœbic dysentery in man; namely, *Harrisonia perforata* (Blanco) Merrill, *Brucea amarissima* (Loureiro) Merrill, and *Castela nicholsoni* Hooker.

2. *Harrisonia perforata* was not especially toxic for animals; it was readily taken by patients but was inefficacious against amœbæ.

3. *Brucea amarissima* was very toxic for animals, produced nausea readily in patients when taken by mouth, and its action on amœbæ was of little value.

4. *Castela nicholsoni* possesses a distinctly toxic principle, therapeutic doses are well borne by patients, and in five cases it gave prompt relief of symptoms accompanied by the disappearance of the amœbæ.

5. After an interval of several months four of the cases treated with *Castela* were reëxamined. A relapse occurred in

one patient; two others remained perfectly well, but cysts of *Entamœba histolytica* were found in the stool of one; in the fourth no symptoms have appeared, and the stool was negative microscopically on two examinations.

6. This work, taken in conjunction with previous experience, suggests that *Castela nicholsoni* compares very favorably with emetine, both in immediate and in final effects of treatment. The administration of *Castela* can be effected very simply. Neither *Castela nicholsoni* nor emetine, as employed at present, is an ideal agent for the eradication of *Entamœba histolytica* infections in man.

ABSTRACT OF CASES

CASTELA NICHOLSONI

Case 1.—Adult Filipino. Pulmonary tuberculosis. Duration of dysentery ten days. Symptoms started with a chill and fever, and bloody mucous discharges as often as fourteen times daily accompanied by tenesmus. Temperature normal. Stools show numerous *Entamœba histolytica*. Inoculations in kittens produced typical dysentery (Strain II of preceding section). *Castela nicholsoni* started, 2 cubic centimeters being given daily with the evening meal for six days. After the third day of treatment, the number of stools diminished to two or three daily, the blood almost disappeared, but the amœbæ persisted. On the seventh day after starting treatment, an examination of the stools after a saline purge showed a few amœbæ; the dosage of *Castela* was increased to 4 cubic centimeters, given as before, with the evening meal. Three days later no amœbæ were found in the stool and treatment was discontinued. The patient remained apparently well, but ten days after discontinuing treatment, *E. histolytica* was again found in the fæces. *Castela* was given in 4 cubic centimeter amounts daily for three days and the amœbæ again disappeared. The patient was discharged from the hospital eighteen days after treatment was finally discontinued, two successive examinations of the stool after saline purgation showing no amœbæ.

This patient was admitted to the hospital seven months later. He was in an advanced stage of tuberculosis, and the symptoms of dysentery had returned. He was put upon routine treatment of the hospital for dysentery and responded fairly well. He died four weeks later, tuberculosis evidently being an important factor in his death. The autopsy showed tuberculosis of the lungs and intestine, and also some acute amœbic lesions of the large bowel.

Case 2.—Adult Filipino. Onset of dysentery, thirteen years ago. The first attack lasted about sixteen months, and there was one severe recurrence three years ago. The present attack began insidiously a few weeks ago. The patient is now having four to eight bowel movements daily. Large numbers of *Entamœba histolytica* are present. Inoculation of kittens produced typical dysentery (Strain III). A daily dose of 5 cubic

centimeters of *Castela* was given for four days. On the third day after treatment no amœbæ were found in the stools; there was marked constipation during the latter half of the first week after treatment was started. Treatment was suspended for eight days, the stools remaining negative for amœbæ. Then a second course of *Castela* was given, using 5 cubic centimeters daily for one week. An examination of the stools four days after the last dose of *Castela* showed no amœbæ. The patient insisted on leaving the hospital, to return to the harvest fields. He has not been seen since.

Case 3.—Adult Filipina. Duration of disease, four months. During this time there have been several partial remissions and a few isolated doses of emetine have been given. At present the patient is having as many as twenty scanty, bloody, mucous stools daily with much tenesmus. She suffers from general malaise, abdominal pain, and marked tenderness along the ascending, descending, and transverse colon. The stools show numerous *Entamœba histolytica,* and kittens were readily infected (Strain IV). *Castela* was given in 4 cubic centimeter doses daily for one week. Constipation set in after the second dose. A stool obtained by a saline purge on the third day of treatment showed no blood, mucus, nor amœbæ. The patient left the hospital against advice at the end of the first week. This patient was seen nine and one-half months later. She had remained entirely free from symptoms and had gained markedly in weight. An examination of the stool showed no amœbæ, and concentration by the method of Cropper and Row (2) showed no cysts.

Case 4.—Adult Filipina. Onset of dysentery three days ago during convalescence from typhoid fever. Large numbers of *Entamœba histolytica* were present in stool; these were virulent for kittens (Strain IV). Daily doses of *Castela* of 5 cubic centimeters were given for five successive days. Constipation developed on the third day of treatment. A stool specimen examined one week after discontinuing *Castela* was negative for blood and amœbæ. Nine months later the patient was in good health. A specimen of stool showed no amœbæ, and no cysts were found after concentration. A second stool specimen obtained two weeks later after a saline purge was likewise negative.

Case 5.—Filipino child, aged 10 years. Duration of disease two weeks. Acute onset with bloody, mucous stools. *Entamœba histolytica* abundant, producing a typical infection in kittens (Strain V). *Castela* given in 2 cubic centimeter doses daily for eight days. The symptoms improved promptly. On the second day after starting treatment, no amœbæ were seen; on the fourth day a single amœba was found; from the fifth day on the examinations were uniformly negative. Ten days after treatment was discontinued the boy was discharged from the hospital. Eight months later he was found to be entirely free from symptoms. A specimen of stool after salts showed four-nucleated cysts of *E. histolytica.*

BRUCEA AMARISSIMA

Case 6.—Adult American. Has had dysentery off and on for two years. The stools contained blood and numerous *Entamœba histolytica.* Kittens

were easily infected. *Brucea* was given in 1 cubic centimeter doses twice daily and caused vomiting on several occasions. During the first five days of treatment the symptoms improved, and the blood gradually disappeared. The amœbæ became rather scarce, but never disappeared altogether. On account of nausea, rectal administration of *Brucea* was started, giving 4 cubic centimeters daily, diluted with 300 cubic centimeters of water. After the third day of rectal treatment, blood appeared in the stools again, the amœbæ were numerous, and the patient was transferred to specific treatment.

Case 7.—Adult Filipina. Onset of dysentery, ten days ago. The stools consisted of blood-streaked mucus; *Entamœba histolytica* present, but in small numbers. *Brucea* was started in 1 cubic centimeter doses, but caused vomiting very regularly. Nevertheless, three days later the amœbæ disappeared from the stools, but the dysentery continued. The coexistence of bacillary dysentery was suspected, but was not confirmed bacteriologically. The patient did not respond definitely to antidysenteric serum, but the symptoms disappeared gradually without further specific treatment. We are not inclined to attribute the disappearance of the amœbæ to the minimal amounts of *Brucea* that were retained.

HARRISONIA PERFORATA

Case 8.—Adult Filipino. Duration of disease very uncertain. The present attack began about eleven days ago with from six to eight bloody, mucous stools daily. *Entamœba histolytica* was present in considerable numbers. Inoculation of a kitten produced typical dysentery (Strain VI). Treatment was started with 30 cubic centimeter quantities of a dilute preparation of *Harrisonia*, given twice daily. On the second day of treatment, the stools were free from blood, and on the third day no stools were passed; on the fourth day a specimen obtained by a saline purge showed no blood nor mucus, but a few motile amœbæ were present. On the eighth day of treatment bloody, mucous stools were passed, containing fairly numerous amœbæ. The *Harrisonia* was discontinued and benzyl benzoate was substituted, giving 2 cubic centimeters of a 20 per cent solution in alcohol three times daily. During the next three days the symptoms increased in severity and amœbæ persisted in large numbers. Accordingly treatment was commenced with *Castela nicholsoni*, giving 5 cubic centimeters daily for seven days. The symptoms and amœbæ disappeared promptly, and the patient has not been seen since that time.

Case 9.—Adult American. Duration of dysentery one and one-half years, with frequent remissions. Has had one short course of emetine. Acute exacerbation a few days ago. *Entamœba histolytica* was abundant in stools. Kittens were infected (Strain VII). *Harrisonia* was given each evening in 50 cubic centimeter dosage for four days. The number of stools diminished somewhat and the patient felt more comfortable, but the excretion of blood, containing active amœbæ, continued. The dosage of *Harrisonia* was then changed to 20 cubic centimeters, given three times daily. The stools showed blood and amœbæ constantly and, four days later, there was a distinct exacerbation of symptoms. The *Harrisonia* was discontinued and specific treatment started. The quantities of *Harrisonia* given were tolerated without discomfort.

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THE EFFECT OF STASIS ON THE DEVELOPMENT OF AMŒBIC DYSENTERY IN THE CAT

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Extensive experimentation in the transmission of amœbic dysentery to lower animals has served to emphasize three apparently unrelated facts: (*a*) During the subpassage of virulent strains of *Entamœba histolytica* through a long series of kittens, by rectal inoculation, a few individuals from time to time escape infection; on reinoculation these animals are found to be just as susceptible as are normal animals; (*b*) on the contrary, when the cæcum is exposed by laparotomy and the infective material introduced directly through the wall of the cæcum into the lumen of the bowel, then infection takes place with surprising regularity; (*c*) in either case, whether the amœbæ are introduced into the cæcum or injected per rectum, the initial lesions occur in the extreme lower portion of the large bowel.

The occasional failure to infect a susceptible kitten with virulent amœbæ injected per rectum is not of itself remarkable, the conditions naturally being somewhat uncertain as compared with the injection of virulent protozoa and bacteria directly into the tissues. The explanation for the constancy of infection after intracæcal inoculation is not immediately apparent. Indeed, some authors, inexperienced in this mode of inoculation, have denied the value of the procedure. The lesions develop, not at the site of inoculation, but at the opposite end of the large bowel. From the location of the early lesions it would be altogether imposible to determine whether a kitten had been injected per rectum or into the cæcum. In any case, it seems a little strange that the upper two-thirds of the large bowel, which is practically a straight tube in the kitten, should escape damage until after the process has secured a firm foothold in the lowermost portion. It seemed to us not improbable that one single

factor might have an important bearing on these three features. Certainly, the short and straight large intestine of the kitten presents no striking differences along its course. However, the contents of the proximal two-thirds are fluid, while in the lower third there occur formed fæces with moderate secretion of mucus. The question of how *Entamœba histolytica* can injure and penetrate the normal mucosa has been much discussed, but this point of stasis in the distal end of the bowel certainly affords an opportunity for the organisms to gain a foothold. The subsequent dissemination of the lesions indicates that there are no pronounced differences physiologically in the susceptibility of various areas of the large bowel.

The importance of stasis as a factor in determining the location of the initial lesions was tested experimentally. The large intestine of a half-grown cat was exposed by laparotomy under general anæsthesia. A broad ligature was placed around the middle of the bowel and tied tightly enough to obstruct the lumen. A suspension of *Entamœba histolytica,* obtained by sacrificing an infected cat, was injected into the cæcum. There was no indication of any postoperative discomfort. Two days later, the animal was sacrificed. Below the ligature the large intestine was practically free of fæcal matter and showed no lesions. Above the ligature, in the cæcum, 3 centimeters from the point of inoculation, one well-developed lesion was present which contained numerous individuals of *E. histolytica.*

In a second experiment, two adult animals were operated upon in the same way, the ligature being placed at the junction of the upper and the middle thirds of the large bowel. The inoculation of amœbæ was made through the tip of the cæcum. At the same time, ten other animals that were to be used for other work were inoculated per rectum under general anæsthesia. These ten were injected with amœbæ before the inoculations were performed on the two that required operation. The time that elapsed between the sacrificing of the infected kitten for the amœbic material and the completion of the inoculations was one hour and twenty minutes. Of the animals receiving rectal injections, two kittens and one half-grown cat became infected; the other seven remained negative. The two adults, inoculated intracæcally, were sacrificed on the third day. Both showed extensive lesions. In one, the bowel below the ligature contained only clear viscid fluid in which a few individuals of *Entamœba histolytica* were seen. There was no trace of macroscopic lesions. Immediately above the ligature, there was

moderate impaction of fæces. In the cæcal end there was extensive superficial erosion of the mucosa, with a few hæmorrhagic areas. The entamœbæ were extremely abundant in the scrapings from the mucosa. In the other cat, just below the ligature, there was a very little fluid which contained a few amœbæ; otherwise, the distal portion of the bowel was very dry and it was free from any lesion. The contents of the proximal portion were fluid, and practically the entire mucosa of the cæcal end showed superficial lesions. Enormous numbers of *Entamœba histolytica* were present. The results of this experiment are summarized in Table 1.

TABLE 1.—*Inoculation of amœbæ per rectum and intracæcally.*

Cat No.	Weight.	Inoculation.	Result.
	g.		
1	2,370	Per rectum	Negative.
2	1,820	do	Do.
3	1,970	do	Do.
4	1,820	do	Do.
5	1,600	do	Do.
6	1,370	do	Do.
7	1,360	do	Positive.
8	1,500	do	Negative.
9	800	do	Positive.
10	860	do	Do.
11	2,400	Intracæcal	Do.
12	2,800	do	Do.

These brief experiments illustrate clearly the importance of stasis as one of the factors in determining the location of the initial lesions in experimental amœbic dysentery in the cat. The distribution of the lesions of amœbic dysentery in man varies considerably. In long-standing fatal cases there is naturally an opportunity for the various portions of the entire large bowel to become involved. Nevertheless, there is a tendency for the ulcerations to predominate, first of all, in the cæcum and ascending colon and, secondly, in the rectum and sigmoid and also at the flexures. These are obviously points at which stasis is likely to occur.

During the past nine months we have on two occasions noted the development of amœbic dysentery during convalescence from typhoid fever. In the observation of more than two hundred cases of Asiatic cholera we have not seen this complication.

The ease with which the two adult cats were infected by intracæcal inoculation is striking. Following the injections per rectum, four adult cats remained well and of four young cats, a

little more than half grown, only one became infected. This illustrates the value of operative procedures for insuring amœbic infection under special conditions. In our own work, in localities where amœbic cases are common, we ordinarily inoculate several kittens per rectum under general anæsthesia, passing a small soft catheter with as little disturbance as possible. However, if young kittens do not happen to be available, or if working in a locality where amœbic dysentery is rare, we always inoculate some animals intracæcally. By this procedure, the amœbæ are introduced into the bowel without breaking up the formed fæces in the rectum, the general anæsthesia and the laparotomy tending to produce constipation.

We have endeavored to utilize some operative procedures in experiments on monkeys. The frequency with which monkeys are parasitized by entamœbæ complicates the interpretation of the results of inoculating them with *Entamœba histolytica*. To obviate some of the difficulty arising from spontaneous infection, the following experiment was carried out. A laparotomy was done on a monkey (*Pithecus philippinensis*) under general anæsthesia, and a ligature was passed around the tip of the rather long cæcum without interfering with the ileocæcal valve. The needle of a syringe was passed through the tip of the cæcum, and the amœbæ were inoculated directly into this sac. It seemed not impossible that in healthy monkeys lesions might be obtained in this sac and not in other parts of the bowel. Thus far, some suggestive but no conclusive results have been obtained.

SUMMARY

1. A laparotomy was performed on three cats under general anæsthesia and a ligature placed around the large bowel in order to produce stasis in its upper end. A suspension of *Entamœba histolytica* was inoculated into the cæcum. All three animals developed lesions above the ligature.

2. This experiment elucidates one factor in explaining (*a*) the usual occurrence of the initial lesions of amœbic dysentery in the cat in the lowermost portion of the large bowel; (*b*) the superiority of intracæcal inoculations over injections per rectum for insuring infection with amœbæ; and (*c*) the occasional failure of virulent amœbæ to infect susceptible kittens.

3. Stasis is probably an important factor in determining the location of the lesions within the large bowel in spontaneous amœbic dysentery in man.

CHEMICAL CHARACTERS OF THE WATERS OF ANGAT AND MONTALBAN RIVERS

By R. H. Aguilar

Of the Bureau of Science, Manila

ONE PLATE

At the request of the Metropolitan Water District of Manila, a systematic study of the quality of the waters of Angat River and its most important tributaries was undertaken by the Bureau of Science. This study, however, was limited to the portion within the mountainous regions northeast of Bulacan Province, comprising an area of about 732 square kilometers. No surface water in the Philippine Islands has ever been so systematically and thoroughly studied as has this river water, not even excluding Montalban River, which is the present source of the water supply for Manila.

A survey of the river was made in May, 1921, by a party of chemists of the division of general, inorganic, and physical chemistry of the Bureau of Science for the purpose of taking observations in situ and selecting convenient stations for collecting water samples for analysis.

Six stations were established along the course of the river, within the territory under observation, and their exact locations are shown in the accompanying sketch (Plate 1). The daily collection of samples, at 6 a. m. and at 6 p. m., began May 21, 1921, and continued for one year. Composite samples made up of seven days' collections from each station were forwarded to the laboratory in Manila for analysis.

In as much as no work of this nature had ever been done on the water from the present source of the Manila water supply, it was thought advisable to locate a seventh station, on Montalban River, about 2 kilometers above the dam. The collection of water samples from this station began July 28, 1921.

The work of investigation is now far enough advanced (May, 1922) to justify the discussion of the chemical characteristics of the waters, the relation of their various chemical constituents with the general geology of the drainage areas, and their value for industrial purposes. The notes on the survey and the re-

sults of analyses and observations on the seasonal variation of the physical and chemical properties of the waters will be the subject of another paper, to be submitted, in the form of a report, to the manager of the Metropolitan Water District, in the latter part of the present year.

STATEMENT OF ANALYTICAL RESULTS

The statement of water analyses that is now almost universally adopted is the ionic form. This form, however, is not per se sufficient to permit one to judge the chemical character of a water. For this purpose the reacting value of each individual radicle for a given analysis must be determined.

Stabler defines the reacting value [1] of a radicle as the product obtained by multiplying the quantity of that radicle, expressed in parts per million, by its reaction coefficient. The reaction coefficient, on the other hand, is the capacity of a unit weight of the radicle to enter into chemical reaction. Hence, if

V = capacity for reaction or valence,

W = atomic or molecular weight of radicle,

M = quantity of the radicle in parts per million,

then,

$$\text{Reacting value} = \frac{V \times M}{W}.$$

The value $\frac{V}{W}$ is the reaction coefficient.

The different values of the radicles are thus resolved into quantities that are chemically measurable by a common standard; namely, hydrogen (H), which is the universally accepted standard of reaction.

REACTING VALUES OF RADICLES AND CHEMICAL PROPERTIES OF WATERS

If the different reacting values obtained according to the above formula are expressed in percentages of the concentration value, the peculiar characteristics of a water due to its mineralization will be very much in evidence. Such expressions form the character formula of a water, by means of which it is possible to establish its relation with the general geology of the country. The character formula, or the reacting values, may

[1] The industrial application of water analysis, U. S. Geol. Surv. Water-Supply Paper 274 (1911) 167.

also be employed to study its adaptability for use in various industrial works.

Adopting the methods followed by Chase Palmer,[2] the waters taken from the six stations on Angat River, and the station on Montalban River may be considered under Class 1.

[2] The geochemical interpretation of water analysis, Bull. U. S. Geol. Survey 479 (1911) 11.

The positive radicles determined in water analysis fall into three groups, as follows:

Group A. Alkalies: sodium (Na′), potassium (K′), lithium (Li′).
Group B. Earths: calcium (Ca″), magnesium (Mg″), iron (Fe″).
Group C. Hydrogen (H′).

From these three groups, five special properties are possible, according to the prevalence of the reacting values of the groups measured by the sum of the reacting values of their members, namely:

1. Primary salinity, or alkali salinity.
2. Secondary salinity, or permanent hardness.
3. Tertiary salinity, or acidity.
4. Primary alkalinity, or permanent alkalinity.
5. Secondary alkalinity, or temporary alkalinity.

CLASSIFICATION OF WATERS

If the above groups A and B represent, respectively, the percentage values of alkalies and earths and another group, D, the percentage values of strong acids; namely, sulphates ($''So_4$), chlorides ($'Cl$), nitrates ($'NO_3$), any one of the following five conditions may occur, representing five different classes of water:

CLASS 1. (D less than A.)

2D	Primary salinity.
2(A−D)	Primary alkalinity.
2B	Secondary alkalinity.

CLASS 2. (D equal to A.)

2A or 2D	Primary salinity.
2B	Secondary alkalinity.

CLASS 3. (D greater than A; less than A+B.)

2A	Primary salinity.
2(D−A)	Secondary salinity.
2(A+B−D)	Secondary alkalinity.

CLASS 4. (D equal to A+B.)

2A	Primary salinity.
2B	Secondary salinity.

CLASS 5. (D greater than A+B.)

2A	Primary salinity.
2B	Secondary salinity.
2(D−(A+B))	Tertiary salinity (acidity).

The following tables show the base data, in parts per million, and the results of computations from which the properties of the waters are derived:

TABLE 1.—*Results of analyses and computations (station 1).*

[Period of observations, May 21 to September 11, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	9.1	0.396	11.79
Potassium (K)	3.4	0.087	2.58
Calcium (Ca)	15.9	0.794	23.63
Magnesium (Mg)	4.9	0.403	12.00
Iron (Fe)	0.03	0.001	0.03
Sulphate (SO_4)	10.5	0.218	6.48
Chloride (Cl)	7.2	0.203	6.04
Nitrate (NO_3)	0.56	0.009	0.27
Bicarbonate (HCO_3)	76.00	1.249	37.18
Concentration value		3.360	100.00
Colloids:			
Silica (SiO_2)	33		
Alumina (Al_2O_3)	1.03		
Groups:			
Alkalies			14.37
Earths			35.66
Strong acids			12.79
Weak acids			37.18
			100.00
Properties:			
Primary salinity			25.6
Primary alkalinity			3.1
Secondary alkalinity			71.3
			100.00

GENERAL CHARACTER OF THE WATERS

The waters from Angat and Montalban Rivers are characterized by primary salinity and primary alkalinity, which properties are generally associated with the older rock formations, the alkalies of which are their principal soluble decomposition products. Excess of alkalinity also indicates that the carbonates of the alkalies are present in the waters in sufficient quantities to overcome all permanent hardness.

The proportion of silica in these waters is also high. In this connection, Palmer [3] expresses himself in the following way:

[3] Bull. U. S. Geol. Survey 479 (1911) 22.

A high proportion of silica in the mineral content of surface waters is thought by many observers to be normal only to small streams flowing from crystalline siliceous rocks, and especially to those streams near their sources; that is, if silica is a prominent constituent of the inorganic material dissolved in the water of a large stream, its presence must be attributed to some extraneous cause, such as tropical climatic conditions in the drainage basin or abundance of organic matter in the waters.

TABLE 2.—*Results of analyses and computations (station 2).*

[Period of observations, May 21 to September 11, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	8.6	0.374	9.89
Potassium (K)	4.8	0.123	3.25
Calcium (Ca)	19.6	0.979	25.92
Magnesium (Mg)	5.0	0.411	10.88
Iron (Fe)	0.04	0.001	0.03
Sulphate (SO_4)	7.9	0.164	4.34
Chloride (Cl)	7.9	0.223	5.90
Nitrate (NO_3)	0.39	0.006	0.16
Bicarbonate (HCO_3)	91.3	1.498	39.63
Concentration value		3.779	100.00
Colloids:			
Silica (SiO_2)	35.0		
Alumina (Al_2O_3)	2.0		
Groups:			
Alkalies			13.14
Earths			36.83
Strong acids			10.40
Weak acids			39.63
			100.00
Properties:			
Primary salinity			20.8
Primary alkalinity			5.5
Secondary alkalinity			73.7
			100.0

Looking over the chemical analyses of some river waters in the Philippine Islands,[4] it is apparent that high silica content is a general characteristic of Philippine river waters; on the other hand, analyses of various river waters in the United States [5] show on the average a much lower silica content. These results seem to indicate that the tropical climatic condition is

[4] Heise, G. W., and Behrman, A. S., Philippine water supplies, Bureau of Science publication 11 (1918) 148–151.

[5] Dole, R. B., U. S. Geol. Surv. Water-Supply Paper 236 (1909).

TABLE 3.—*Results of analyses and computations (station 3).*

[Period of observations, May 21 to September 11, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	9.1	0.396	12.20
Potassium (K)	3.6	0.092	2.83
Calcium (Ca)	15.3	0.764	23.55
Magnesium (Mg)	4.5	0.370	11.40
Iron (Fe)	0.06	0.002	0.06
Sulphate (SO_4)	9.2	0.191	5.92
Chloride (Cl)	7.4	0.209	6.44
Nitrate (NO_3)	0.31	0.005	0.16
Bicarbonate (HCO_3)	74.0	1.215	37.44
Concentration value		3.244	100.00
Colloids:			
Silica (SiO_2)	35.0		
Alumina (Al_2O_3)	2.0		
Groups:			
Alkalies			15.03
Earths			35.01
Strong acids			12.52
Weak acids			37.44
			100.00
Properties:			
Primary salinity			25.0
Primary alkalinity			5.0
Secondary alkalinity			70.0
			100.0

an important factor in the dissolution of the siliceous materials of rocks. It is further observed that the waters of Angat and Montalban Rivers are primarily alkaline; and the solvent action of alkalies on silica, even in very dilute solutions, has long been recognized. The organic matter in these waters is too small to be worthy of consideration.

CHEMICAL PROPERTIES AND GEOLOGY OF THE DRAINAGE AREAS

There is a remarkable similarity in the property values of the waters at station 5 and station 7. Station 5 is situated at Ipo, and station 7 at Montalban River. Both waters are characterized by low primary salinity and high primary alkalinity. On the other hand, the water at station 1 is characterized by high primary salinity and low primary alkalinity. This apparent difference in the chemical characters of the waters at

TABLE 4.—*Results of analyses and computations (station 4).*

[Period of observations, May 17 to August 23, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	9.7	0.422	11.61
Potassium (K)	1.95	0.050	1.38
Calcium (Ca)	18.3	0.915	25.17
Magnesium (Mg)	5.2	0.427	11.75
Iron (Fe)	0.08	0.003	0.08
Sulphate (SO_4)	10.2	0.212	5.83
Chloride (Cl)	6.9	0.195	5.36
Nitrate (NO_3)	0.25	0.004	0.11
Bicarbonate (HCO_3)	85.8	1.407	38.71
Concentration value		3.635	100.00
Colloids:			
Silica	40.0		
Alumina	2.2		
Groups:			
Alkalies			12.99
Earths			37.00
Strong acids			11.30
Weak acids			38.71
			100.00
Properties:			
Primary salinity			22.6
Primary alkalinity			3.4
Secondary alkalinity			75.0
			100.0

station 1 and station 5 is due to the preponderance of sulphates, which probably are oxidized decomposition products of iron pyrites. It is well to note, in this connection, that a portion of the watershed of Talaguio River is situated within the district of the Angat iron mines, and its waters are sampled at station 1 together with the waters of Maputi and Kailugan. With the exception of the saline waters at Talaguio River, the waters of the various tributaries of Angat River and also those of Montalban River are characterized by primary alkalinity, indicating the predominating influence of beds of decomposed igneous and crystalline granitic rocks in their drainage basins. Secondary alkalinity, causing temporary hardness, is also a conspicuous property common to all these waters, acquired no doubt through contact with limestone deposits.

TABLE 5.—*Results of analyses and computations (station 5).*

[Period of observations, May 17 to August 23, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	8.8	0.383	10.09
Potassium (K)	1.9	0.049	1.30
Calcium (Ca)	17.5	0.878	23.13
Magnesium (Mg)	7.1	0.584	15.37
Iron (Fe)	0.11	0.004	0.11
Sulphate (SO_4)	5.2	0.108	2.84
Chloride (Cl)	6.7	0.189	4.97
Nitrate (NO_3)	0.28	0.004	0.11
Bicarbonate (HCO_3)	97.5	1.599	42.08
Concentration value		3.798	100.00
Colloids:			
Silica (SiO_2)	39.0		
Alumina (Al_2O_3)	2.2		
Groups:			
Alkalies			11.39
Earths			38.61
Strong acids			7.92
Weak acids			42.08
			100.00
Properties:			
Primary salinity			15.9
Primary alkalinity			6.9
Secondary alkalinity			77.2
			100.00

REACTING VALUES AND INDUSTRIAL USEFULNESS

In discussing the industrial usefulness of the waters as computed from the reacting values of their various constituents, use is here made of the formulæ developed by Stabler.[6] The expressions, however, are here recalculated in terms of kilograms per cubic meter of water.

Formula 1.—Lime requirements (100 per cent CaO).

$$CaO = 0.0281 \quad (rFe + rAl + rMg + rH + rHCO_3 + 0.0454\ CO_2).^{7}$$

Formula 2.—Soda requirements (100 per cent Na_2CO_3).

$$Na_2CO_3 = 0.053 \quad (rFe + rAl + rCa + rMg + rH - (2CO_3 + rHCO_3).$$

[6] The industrial application of water analyses, U. S. Geol. Surv. Water Supply Paper 274 (1911) 165–181.

[7] r = reaction coefficient.

TABLE 6.—*Results of analyses and computations (station 6).*

[Period of observations, May 23 to September 7, 1921. Number of composite samples, 14.]

	Average anlysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{(V \times M)}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	9.7	0.422	12.10
Potassium (K)	1.8	0.046	1.32
Calcium (Ca)	17.3	0.864	24.78
Magnesium (Mg)	5.2	0.427	12.25
Iron (Fe)	0.07	0.002	0.06
Sulphate (SO_4)	9.2	0.191	5.48
Chloride (Cl)	6.5	0.183	5.25
Nitrate (NO_3)	0.29	0.005	0.14
Bicarbonate (HCO_3)	82.0	1.346	38.62
Concentration value		3.486	100.00
Colloids:			
Silica (SiO_2)	36.0		
Alumina (Al_2O_3)	1.9		
Groups:			
Alkalies			13.42
Earths			37.09
Strong acids			10.87
Weak acids			38.62
			100.00
Properties:			
Primary salinity			21.7
Primary akalinity			5.1
Secondary alkalinity			74.2
			100.0

A negative value indicates that no soda is required.

Formula 3.—Foaming and priming coefficient.

$$F = 62\ (rNa + 1.258\ rK).$$

VALUATION

Nonfoaming	$F < 60$
Semifoaming	$F > 60$, but < 200
Foaming	$F > 200$

Formula 4.—Corrosion coefficient.

$$C = 1.008\ (rH + rAl + rFe + rMg - (rCO_3 + rHCO_3).$$

VALUATION

Corrosive	C, positive
Noncorrosive	(C + 1.008 rCa), negative
Semicorrosive	(C + 1.008 rCa), positive [8]

[8] Corrosiveness is directly proportional to the value of (C + 1.008 rCa).

TABLE 7.—*Results of analyses and computations (station 7).*

[Period of observations, July 28 to November 16, 1921. Number of composite samples, 14.]

	Average analysis.	Reacting values.	
	Parts per million.	*Mg. per liter.* $\frac{V \times M}{W}$	*Per cent.*
Radicles:			
Sodium (Na)	8.9	0.390	8.99
Potassium (K)	2.5	0.064	1.48
Calcium (Ca)	25.9	1.293	29.79
Magnesium (Mg)	5.1	0.419	9.65
Iron (Fe)	0.1	0.004	0.09
Sulphate (SO_4)	4.7	0.098	2.26
Chloride (Cl)	7.4	0.209	4.81
Nitrate (NO_3)	0.3	0.005	0.11
Bicarbonate (HCO_3)	113.0	1.858	42.82
Concentration value		4.340	100.00
Colloids:			
Silica (SiO_2)	38.0		
Alumina (Al_2O_3)	2.2		
Groups:			
Alkalies			10.47
Earths			39.53
Strong acids			7.18
Weak acids			42.82
			100.00
Properties:			
Primary salinity			14.4
Primary alkalinity			6.6
Secondary alkalinity			79.0
			100.00

Formula 5.—Scale formation.

(*a*) Total scale.

$$Sc = 0.001\ Sm^{9} + 0.001\ Cm^{10} + 0.036\ rFe + 0.017\ rAl + 0.02\ rMg + 0.06\ rCa.$$

rCa must not exceed the value of $(rCO_3 + rHCO_3 + rSO_4)$.

(*b*) Hard scale.

$$Hs = 0.001\ SiO_2 + 0.02\ rMg + 0.068\ (rCl + rSO_4 - rNa - rK).$$

Coefficient of scale hardness $h = \frac{Hs}{Sc}$.

[9] Suspended matter. [10] Colloidal matter.

VALUATION

Soft scale	$h < 0.25$
Medium scale	$h > 0.25$, but < 0.5
Hard scale	$h > 0.5$

PREFIXES

Very little	$Sc < 0.12$
Little	$Sc > 0.12$, but < 0.24
Much	$Sc > 0.24$, but < 0.48
Very much	$Sc > 0.48$

If the percentage expressions of the various constituents are used instead of their values in milligrams per liter, the results must be multiplied by the expression:

$$\frac{\text{Concentration value}}{100}.$$

TABLE 8.—*Application of formulas and valuation of the waters for industrial purposes.*

[Figures express kilograms per cubic meter.]

Station.	Chemical treatment.		Foaming and priming properties.	Corrosiveness.	Scale formation.
	CaO required.	Na_2CO_3 required.			
1	0.046	None	Nonfoaming.	Noncorrosive.	Very little medium scale.
2	0.054	do	do	do	Do.
3	0.045	do	do	do	Do.
4	0.052	do	do	do	Do.
5	0.061	do	do	do	Do.
6	0.050	do	do	do	Do.
7	0.064	do	do	do	Little medium scale.

The results shown in Table 8 are self-explanatory as to the quality of the waters for industrial purposes.

SUMMARY

The general characteristics of the waters of Angat and Montalban Rivers are primary salinity and secondary alkalinity. The alkalies are also present in sufficient quantities to overcome all permanent hardness.

The high sulphate content of the waters at Stations 1, 3, 4, and 6 is probably due to the oxidized decomposition products of iron pyrites with which Talaguio River appears to be contaminated.

The waters are nonfoaming, noncorrosive, and, from a chemical point of view, they may be considered satisfactory for general public consumption.

ILLUSTRATION

PLATE 1. Topographic map of the Angat River watershed, showing the location of six stations.

PLATE 1. ANGAT RIVER WATERSHED, SHOWING THE LOCATION OF SIX STATIONS.

LYCOPODIACEAE PHILIPPINENSES

Von W. Herter

Berlin, Germany

Vor einem Jahrzehnt sandte mir der bekannte Botaniker der Philippinen, Herr Elmer D. Merrill, Director, Bureau of Science, Manila, eine wertvolle Sammlung philippinischer Lycopodien zur Bearbeitung nach Porto Alegre, Rio Grande de Sul, meiner damaligen Wirkungsstätte. Als ich bald darauf, im Jahre 1913, nach Deutschland zurückkehrte, gelang es die Sammlung nach Berlin-Dahlem zu schaffen, wo ich sie an der Hand des Herbariums des Botanischen Museums bearbeiten konnte und wo ich im Jahre 1915 ein Manuskript über die Lycopodiaceen der Philippinen fertigstellte. Dieses Manuskript verschwand spurlos während meines Sanitätsdienstes bei der Ostarmee, sodass eine unliebsame Verzögerung der Drucklegung eintrat und ich nach meiner Rückkehr nach Berlin die Arbeit von neuem anfangen musste. Kurz vor Abschluss der Neubearbeitung übersandte mir im Jahre 1921 Herr Merrill eine weitere, noch reichhaltigere Lycopodiensammlung, die in der Zwischenzeit auf den Philippinen zusammengebracht worden war und die im Verein mit der ersten Sammlung ein recht vollständiges Bild der Lycopodiaceenflora jener Inseln ergibt.

Im Folgenden habe ich die Ergebnisse meiner Studien der beiden Sammlungen zusammengestellt.

ERSTER TEIL

SCHLÜSSEL DER GATTUNGEN, UNTERGATTUNGEN, SEKTIONEN, UND ARTEN

Die Familie der Lycopodiaceen zerfällt in zwei Gattungen: *Urostachys* und *Lycopodium*.

Genus UROSTACHYS Herter

Verzweigung in allen (vegetativen und reproduktiven) Teilen bipartit mit gleichmässiger Weiterentwickelung. Infolgedessen fehlt eine Hauptachse. Wurzeln in Büscheln nahe dem Anfangsende der Pflanze, soweit sich dieses am Boden befindet, nur ausnahmsweise Adventivwurzeln an sonstigen dem Substrat genäherten Stellen der Pflanze. Bisweilen Brutknospen am ober-

en Ende der Pflanze. Sporangien am ganzen Stamm verteilt oder nur an den Zweigenden in undeutlich, seltener deutlich abgesetzten, ungestielten, bisweilen sehr langen und viel verzweigten Blüten, die stets geringeren Durchmesser haben als die vegetativen Teile. Sporophylle (Sporangien tragende Blätter) den Blättern meist gleich oder ähnlich gestaltet und gefärbt, seltener stark verschieden, dick und gekielt. Sporen glatt oder unregelmässig rauh, mit punktförmigen Vertiefungen. Geschlechtsorgane mit Paraphysen. Am Boden oder auf Bäumen lebende, aufrechte oder herabhängende, gleichmässig beblätterte Pflanzen.

*a*¹. Sporophylle den Blättern gleich gestaltet oder von ihnen verschieden; im letzteren Falle (Sectionen *Squarrosurus* und *Carinaturus*) unmerklicher Uebergang zwischen beiden, selten sind deutlich abgesetzte Blüten vorhanden, dann ist jedoch eine mindestens 2 cm lange Uebergangszone zwischen vegetativem Teil und Blüte vorhanden und letztere ist breiter als 3 mm. Aufrechte Geophyten und hängende Epiphyten..... Subgenus **Euurostachys** Hert.

*b*¹. Sporophylle und Blätter völlig oder ziemlich gleichgestaltet. Oft Brutknospen vorhanden. Keine eigentlichen Blüten.

*c*¹. Geophyten. Aufrechte, meist 10–20 cm hohe Pflanzen. Blätter linearisch oder lanzettlich. Brutknospen vorhanden. Sectio *Selaginurus* Hert.

*d*¹. Höhe 10 cm. Blätter in der Nähe des Blattgrundes am breitesten, mittlere Breite 0.3 mm..... 1. **U. minimus** Hert.

*d*². Oft 20 cm hoch und höher. Blätter in der Nähe der Blattmitte am breitesten, oft über 1 mm. breit. 2. **U. serratus** (Thunb.) Hert.

*c*². Epiphyten. Herabhängende, 30–300 cm lange Pflanzen. Blätter fadenförmig. Durchmesser der Zweige (einschliesslich der Blätter) oben und unten gleich. Blätter 3–7 mm lang. Keine Brutknospen. Sectio *Tenuistachys* Hert. 3. **U. verticillatus** (L.) Hert.

*b*². Sporophylle und Blätter meist recht verschieden gestaltet, jedoch allmählich in einander übergehend. Ohne Brutknospen. Ephiphyten.

*c*¹. Blüten kaum oder deutlicher abgesetzt, Sporophylle und Blätter wenig oder stärker verschieden, Sporophylle nicht oder schwach gekielt. Blätter linearlanzettlich, wagerecht abstehend, lederig, flach. Pflanzen kräftig, meist aufrecht. Stamm ohne Blätter, an der Basis oft über 5 mm dick..... Sectio *Squarrosurus* Hert.

*d*¹. Blüten gewöhnlich breiter als 10 mm, seltener an der Spitze nur 6–8 mm breit. Sporophylle abstehend, den Blättern meist sehr ähnlich, 0.5–1.5 x 6–8 mm gross. 4. **U. squarrosus** (Forst.) Hert.

*d*². Blüten in der Mitte 4–8 mm breit. Sporophylle anliegend, von den Blättern abweichend gestaltet, 1–1.5 x 4–5 mm gross.

e^1. Blüten in der Mitte 6–8 mm breit. Blätter glänzend. Sporophylle 1.5 x 5 mm gross ..... 5. **U. Magnusianus** Hert.

e^2. Blüten in der Mitte 4–5 mm breit, Blätter nicht glänzend. Sporophylle 1 x 5 mm gross ..... 6. **U. Whitfordi** Hert.

c^2. Sporophylle und Blätter völlig verschieden, erstere stets scharf gekielt. Pflanzen meist schlaff herabhängend. Stamm ohne Blätter bis 3 mm dick ..... Sectio *Carinaturus* Hert.

d^1. Blätter linearlanzettlich, lederig, wagerecht abstehend, flach, abwärts gekrümmt, Sporophylle mässig starr. 7. **U. Toppingi** Hert.

d^2. Blätter aufrecht abstehend, Sporophylle sehr starr und regelmässig gestellt.

e^1. Untere Blätter starr linearisch, Blätter 8 mm lang. 8. **U. carinatus** (Desv.) Hert.

e^2. Untere Blätter lanzettlich, lederig, 10–12 mm lang. 9. **U. Merrilli** Hert.

a^2. Sporophylle von den Blättern stets verschieden, ganz bedeutend kleiner als diese, meist breit eiförmig. Blüten scharf abgesetzt, oft gegabelt, bisweilen durch fadenförmige Schlankheit ausgezeichnet, meist 1–2, selten bis 5 mm breit. Herabhängende Epiphyten. Subgenus **Heterourostachys** Hert.

b^1. Blätter gespitzt ..... Sectio *Phlegmariurus* Hert.

c^1. Blätter mehr als doppelt so lang als breit.

d^1. Blüten dicker als 3 mm, wenig verzweigt. Schlaff herabhängend. 10. **U. pinifolius** (Blume) Hert.

d^2. Blüten dünner als 3 mm, Gebeläste oft stark spreizend und vielfach gekrümmt.

e^1. Blätter dicht, aufrecht abstehend, fest, lederig, 4–5 x 15–20 mm lang, Stamm oft 3 und mehr mm ohne die Blätter breit; Sporophylle dicht stehend, etwa so breit als die Sporangien, diese meist bedeckend. Robuste Pflanze. 11. **U. Elmeri** Hert.

e^2. Blätter locker abstehend, meist 10 mm lang oder kürzer.

f^1. Blätter 1–3 mm breit ..... 12. **U. banayanicus** Hert.

f^2. Blätter 4–5 mm breit ..... 13. **U. phlegmaria** (L.) Hert.

c^2. Blätter nur wenig länger als breit, eiförmig, stumpf gespitzt. 14. **U. salvinioides** Hert.

b^2. Blätter nicht gespitzt, umgekehrt eiförmig. Blüten 3–4 mm dick. Sectio *Nummulariifoliurus* Hert ..... 15. **U. Delbrückii** Hert.

Genus LYCOPODIUM (L.) Herter

Verzweigung nur in der Jugend (bei älteren Pflanzen meist nur in den jüngeren reproduktiven Teilen) bipartit mit gleichmässiger Weiterentwickelung; später kommt durch ungleichmässige Weiterentwickelung eine Hauptachse zustande, die über oder seltener unter dem Erdboden hinkriecht oder im Gesträuch hochklettert. Sie ist bisweilen sehr kurz (*Lateralistachys*) oder erscheint bei den Halbsträuchern (*Cernuostachys*) in Form von Ausläufern oder Verbindungsgliedern mehrerer, anscheinend selbständiger Pflanzen. Diese Verbindungsglieder fehlen in Herbarien, wenn nur der obere Teil der Pflanze gesammelt

worden ist. Wurzeln in regelmässigen Abständen an der Hauptachse. Brutknospen am oberen Ende der Pflanze fehlen. Sporangien nie am ganzen Stamm verteilt, sondern in mehr oder weniger deutlich abgesetzten endständigen oder seitlichen (*Lateralistachys*) walzen- oder kätzchenförmigen, von den vegetativen Teilen meist durch spärlicher beblätterte Zwischenstücke von geringerem Durchmesser (Blütenstiele) getrennten Blüten. Sporophylle von den Blättern meist stark verschieden, von bleicher oder bräunlicher Farbe, am Rande gezähnt oder gewimpert, oft zart häutig, nie dick und gekielt. Sporen mit erhabenen, netzartigen Verdickungen oder Stacheln. Geschlechtsorgane ohne Paraphysen. Geophyten oder Kletterer, bei denen die Differenzierung in Bezug auf Verzweigung und Beblätterung fortgeschrittener erscheint.

a^1. Blüten am Ende der Zweige oder Blütenstiele.

Subgenus Acrostachys Hert.

b^1. Bodenkriecher. Blüten wenige (meist nur 1–20 an jeder Pflanze). Schleimgänge fehlen.....Sectio *Eulycopodium* Hert. *Clavatostachys* und *Complanatostachys* Hert. olim.

c^1. Blätter von einerlei Art, radiär abstehend. Blüten an langen, blattarmen Stielen..... 1. L. clavatum L.

c^2. Blätter von zweierlei Art, bilateral gestellt, die seitlichen flach, nach oben gekrümmt, abstehend, breit, herablaufend, die vorderen und hinteren (oberen und unteren) kleiner, linear, angedrückt.

d^1. Auch die grösseren Blätter kurz schuppenförmig, bis 2 mm lang, starr spitzig, Zweige mit den Blättern kaum breiter als 2.5 mm. Blüten zu mehreren am Ende der Zweige.

2. L. complanatum L.

d^2. Grössere Blätter bis 5 mm lang, kammförmig abstehend, linear lanzettlich. Zweige aufsteigend, mit den Blättern 5 mm breit. Blüten einzeln am Ende der Zweige.

3. L. scariosum Forst.

b^2. Meterhohe Halbsträucher mit ausläuferartiger Hauptachse (die im Herbarium oft fehlt) oder mit der Hauptachse meterhoch kletternde Pflanzen. Blüten zahlreich, oft 50–100 und mehr.

Sectio *Cernoustachys* Hert.

c^1. Aufrechte Halbsträucher. Blüten als kurze walzenförmige Kätzchen stiellos an den Enden der beblätterten Zweige. Sporophylle mit langer Spitze, gewimpert. Blätter linear-pfriemlich, mit stark hervortretender Mittelrippe und Schleimgängen.

4. L. cernuum L.

c^2. Kletternde Pflanzen. Blüten als gekrümmte Kätzchen an vielfach verzweigten, blattarmen Stielen. Schleimgänge fehlen.

d^1. Vegetative Teile radiär gebaut. Jugendform mit pfriemlich-linearen, abstehenden, Altersform mit schuppigen, angepressten, herablaufenden Blättern. Endzweige oft hängend, rot.

5. L. casuarinoides (Spring).

d^2. Vegetative Teile bilateral gebaut, zwei Reihen seitlicher, sichelförmiger, oft zusammenhängender und zwei Reihen dorsaler, nebeneinander stehender, kleiner, angepresster Blätter. Ueber 10 m hoch kletternd ..... 6. **L. volubile** Forst.

a^2. Wenig verzweigte, niedrige Kräuter mit reduzierter (in Herbarien meist fehlender) Hauptachse, Aeste aufrecht, Blüten seitlich aus den Zweigen hervorkommend. Blätter linear. Subgenus **Lateralistachys** Hert. ..... 7. **L. halconense** Copel.

ZWEITER TEIL

AUFZÄHLUNG DER ARTEN MIT STANDORTEN. BESCHREIBUNG DER NEUEN ARTEN

Genus **UROSTACHYS** Hert. in Beih. Bot. Centralbl. Abt. II 1922. *Lycopodium* Subgenus I. *Urostachys* Hert. in Engl. Bot. Jahrb. 43 (1909) Beibl. 98: 29.

Subgenus **Euurostachys** Hert. op. cit. 30. sensu emend.

Sectio SELAGINURUS Hert. l. c.

UROSTACHYS MINIMUS Hert. sp. nov.

Radix brunnea, fasciculata, pluries bipartita, long. 15 mm, lat. 0.2 mm. Frons viridis, bis-ter bipartita, suberecta v. subflexuosa, tenerrima, alt. 6–8 cm, lat. 4–6 mm foliis inclusis, 0.5 mm foliis exclusis. Folia viridia, ± sexfaria, subdensa, horizontaliter patentia, tenera, lineari, 2–4 x 0.2 mm. Sporangia deficiunt. Planta affinis *U. vernicoso*, sed multo minor, odore typico Lycopodiacearum.

MINDANAO, Davao District, Mount Apo, *Elmer 11560*, August, 1909, herb. Manila.

UROSTACHYS SERRATUS (Thunb.) Hert. comb. nov.
Lycopodium serratum Thunb. Fl. Jap. (1784) 341, *t. 38.*

Area geogr.: As. orient. subarct., temp., subtrop., trop. Ins. Philipp.: LUZON, Lepanto Subprovince, Mount Data, *Copeland 1864:* Bontoc Subprovince, Malawey, *Vanoverbergh 487:* Benguet Subprovince, Pauai, Mount Ugo, Mount Tonglon, *Bur. Sci. 31987 Santos, 4229, 4464 Mearns, 5810 Ramos, 8382 McGregor, For. Bur. 10835 Curran, Merrill Phil. Pl. 906, Topping 1177, Clemens 9228:* Laguna Province, Mount Banahao, *Merrill 7510, Copeland s.n., Bur. Sci. 19569 Ramos.* MINDORO, Mount Halcon, *Merrill 6022, 6023.* NEGROS, Canlaon Volcano, *Merrill 6954.* MINDANAO, Misamis Province, Mount Malindang, *For. Bur. 4648, 4649 Mearns & Hutchinson:* Agusan Province, Mount Urdaneta, *Elmer 14094.* An bemoosten Stämmen in Gebirgswäldern in Höhen von 1,600–2,800 m.

Nom. vulgare: Kodlala (Ig.); sinang padayo (Bon.).

Sectio TENUISTACHYS Hert. l. c.

UROSTACHYS VERTICILLATUS (Linn. f.) Hert. comb. nov. **var. γ MAXIMA** (Hert.) comb. nov.

Lycopodium verticillatum Linn. f. Suppl. (1781) 448, γ *maximum* Hert. in Engl. Bot. Jahrb. 54 (1916) 227.

Var. δ **GIGANTEUS** Hert. var. nov.

Differt diametro giganteo partium sterilium (12–15 mm) et partium fertilium (8–15 mm).

Area geogr. Circumtrop. Ins. Philipp.: LUZON, Ifugao Subprovince, Mount Polis, *Merrill Phil. Pl. 1277* coll. *McGregor*, δ. MINDORO, Mount Halcon, *Merrill 6026*, γ. MINDANAO, Davao District, Mount Matutum, *Copeland* s. n., γ & δ; Mount Apo, *Elmer 11659*, γ: Misamis Province, Mount Malindang, *Bur. Sci. 4652, 4653 Mearns & Hutchinson*, δ. An bemoosten Stämmen in Gebirgswäldern in Höhen von 1,500–2,400 m.

Sectio SQUARROSURUS Hert. sect. nov. Series *Squarrosa* Hert. op. cit. 36.

UROSTACHYS SQUARROSUS (Forst.) Hert. comb. nov.

Lycopodium squarrosum Forst. Prodr. (1786) 86 (Tahiti?).

Var. α **TYPICA.**

Pars fertilis diam. 12–15 mm, folia majora lat. 1–1.5 mm.

Var. β **INTERMEDIA.**

Pars fertilis diam. 10 mm.

Var. γ **TENERA.**

Pars fertilis interdum ad apicem versus non magis quam 6–8 mm diam.; folia minora, lat. 0.5–0.8 mm.

Area geogr.: Regn. paleo-trop.- Ins. Philipp.: BABUYAN ISLANDS, Camiguin, *Bur. Sci. 4142 Fénix*, γ. LUZON, Bontoc Subprovince, Malawey, *Vanoverbergh 489:* Benguet Subprovince, Baguio, *Elmer 6026*, α, *Lete 394*, α, *Topping 230*, α, *Phil. Pl. 1046 Fénix*, α: Tayabas Province, Sampaloc, *Holman 198:* Zambales Province, Mount Tapulao, *Bur. Sci. 5003 Ramos*, β: Pampanga Province, Mount Abu, *Bur. Sci. 1969 Foxworthy*, β: Bataan Province, Mount Mariveles, *Topping 376*, α, *Whitford 325*, α, *Merrill 3959*, β: Albay Province, Mount Mayon, *Bur. Sci. 6463 Robinson*, α. PANAY, Iloilo Province, Ulian River, *Bur. Sci. 18199 Robinson*, β. MINDORO, Mount Halcon, *Merrill 6027*, α, *6028* β. NEGROS, Canlaon Volcano, *Banks*. MINDANAO, Agusan Province, Mount Urdaneta, *Weber 1161*, β & γ, *Elmer 14165*, β: Misamis Province, Mount Malindang, *For. Bur. 4656, 4657, 4658 Mearns & Hutchinson*, α: Lake Lanao, *Clemens, s.n.*, α, Lanao–Cotabato trail, *For. Bur. 25236 Alvarez*, β: Davao District, Mount Apo, *Copeland 999*, α, Elmer *10783*, γ. In

feuchten Wäldern, meist an bemoosten Stämmen, in Höhen von 100–2,500 m.

Nom. vulgare: Padayau (Ig.).

UROSTACHYS MAGNUSIANUS (Hert.) Hert. comb. nov.

Lycopodium Magnusianum Hert. in Hedw. 49 (1909) 91.

Frons lat. basi 16–18 mm foliis inclusis. Flores long 6–8 cm, lat. (6–) 8 mm foliis inclusis.

Area geogr. Ins. Philipp.: MINDANAO, Lamao District, Camp Keithley, *Clemens s. n.* Herb. Man., Herb. Berl. Typus der art!

UROSTACHYS WHITFORDI Hert. sp. nov.

Lycopodium squarrosum var. *McGregorii* Christ in litt. 1905; var. *Whitfordi* Christ et var. *humilis* Christ nom. nud. in Herb. Man.

Radix fasciculata. Frons luteo- sive brunneo-viridis, sexies-octies bipartita, primum probabiliter erecta, deinde pendula, long. 60–100 cm, lat. 20–25 mm foliis inclusis. Caulis rigidus, basi diam. 6–8 mm foliis exclusis. Flores bipartiti, long. saepius 20–30 cm, lat. ad basim 6–8, ceterum 4–5 mm. Folia ± duodecimfaria, densissima, patentia, saepius incurvata, acumine aut ad basin aut ad apicem spectantia, subrigida, sed non crassa, lanceolata, longe acuminata, nec carinata, nec nitida, 1–2 x 8–12 mm.

Sporophylla densissima, erecto-patentia, lanceolata 1 x 4–6 mm, sporangia obtegentia. Sporangia lat. vix 1 mm. Planta epiphytica proxime affinis *U. squarroso* et *U. Magnusiano*, quibus floribus longis et 4–5 mm latis differt.

Area geogr. Ins. Philip.: LUZON, Tayabas (Infanta) Province, *Whitford 798*, Typus der Art! PANAY, Capiz Province, Mount Madiaas, *Bur. Sci. 30687 Ramos & Edaño;* Mount Salibongbong, *Bur. Sci. 35624 Martelino & Edaño.* MINDORO, Baco River, *McGregor 293.* LEYTE, Dagami, *Wenzel 507.* MINDANAO, Surigao Province, *Bolster 358.* BASILAN, *Bur. Sci. 16219 Reillo.* In Wäldern, von Meereshöhe bis 600 m.

Nom. vulgare: Lumayi (Tag.).

Sectio CARINATURUS Hert. op. cit. 30.

UROSTACHYS TOPPINGI Hert. sp. nov.

Radix ramosissima. Frons sordide brunneo-viridis, long. 20–25 cm, quater bipartita, pendula. Caulis basi 2 mm diam. foliis exclusis. Partes steriles 10 (–15) cm lat. foliis inclusis, abruptim in flores transeunt. Flores bipartiti, long. 10 cm, lat. 10 mm. Folia ± octofaria, densa, lineari-lanceolata, plana, acuminata, reflexa, apice ad basim spectante, nervo vix promi-

nente, 1 x 8 mm. Sporophylla quinque-sexfaria, densa, erecto-patentia, lineari-lanceolata, acuminata, carinata, 1 x 4–5 mm. Planta epiphytica intermediaria inter sectiones *Squarrosurus* et *Carinaturus,* primo visu affinis *U. reflexo* videtur foliis angustis lineari-lanceolatis planis reflexis.

Area geogr. Ins. Philipp. LUZON: Benguet Subprovince, Sablan Trail, *Topping 1096* herb. Man. Jan. 1909.

UROSTACHYS CARINATUS (Desv.) Hert. comb. nov.

Lycopodium carinatum Desv. in Lam. Encycl. Suppl. 3 (1823) 559.
Lycopodium gnidioides Blanco Fl. Filip. (1837) 824, non Linn.

Area geogr. As. et Austral. trop. Ins. Philipp.: LUZON, *Haenke 48,* Herb. Berl., *Cuming 2009, 2360* Herb. Berl., Paris, Kew, Delessert: Tayabas Province, *Whitford 813, For. Bur. 9575 Curran:* Bataan Province, Mount Mariveles, *Merrill 152:* Laguna Province, San Antonio, *Bur. Sci. 14950 Ramos.* POLILLO, *Bur. Sci. 10780 McGregor, 9252 Robinson.* MINDORO, Baco River, *Merrill 1245,* MINDANAO, Agusan Province, Bunawan, *Taylor 167:* Lanao District, Camp Keithley, *Clemens 746:* Davao District, *Warburg 14200* Herb. Berl. An Waldbäumen im Flachland bis zu Höhen von 1,200 m.

UROSTACHYS MERRILLI Hert. sp. nov.

Radix fasciculata. Frons sordide luteo- s. brunneo-viridis, flaccide pendula, quinquies bipartita, long. 50 cm. Caulis basi diametro 1–2 mm foliis exclusis. Partes steriles basi 15 mm, apice 10 mm foliis inclusis, abruptim in flores transeunt. Flores bis-quater bipartiti, long. 30 cm, lat. 4–6 mm. Folia sex-octofaria, subdensa, erecto-patentia, subregulariter disposita, ovato-lanceolata, plana, non crassa, acuminata, nervo infra prominente, 2–3 x 8–12 mm. Sporophylla densiora, quadri-sex-faria, erecto-patentia, regulariter disposita, non crassa, lanceolata, carinata, 2–2.5 x 5–6 mm. Planta epiphytica intermedia inter *U. carinatum* et *U. phlegmariam.* Differt ab *U. carinato* textura laxa foliisque planis.

Area geogr. Ins. Philipp.: LUZON, Benguet Subprovince, Mount Lusod, *For. Bur. 15760 Curran & Merritt;* Mount Tonglon (Santo Tomas), *Merrill Phil. Pl. 965* (Typus der Art!), *Elmer 6619, For. Bur. 5064 Curran;* Mount Pulog, *Bur. Sci. 8836 McGregor, For. Bur. 16322 Curran, Merritt, & Zschokke;* Pauai, *Topping 1156, Bur. Sci. 31819 Santos, 8477 McGregor:* Lepanto Subprovince, Mount Data, *Copeland 1872, For. Bur. 10966 Curran:* Bontoc Subprovince, Malawey, *Vanoverbergh 671.* An bemoosten Stämmen in Gebirgswäldern in Höhen von 1,600–2,400 m.

Subgenus Heterourostachys Hert. op. cit. sensu restr.

Sectio PHLEGMARIURUS Hert. op. cit.

UROSTACHYS PINIFOLIUS (Blume) Hert. comb. nov.
Lycopodium pinifolium Blume Enum. Pl. Jav. 2 (1828) 264.

Ich stelle die vorliegenden Pflanzen mit Vorbehalt zu *U. pinifolius,* vielleicht wären sie besser als eigene Art zu betrachten. Das gleiche gilt von einigen Pflanzen von Nordluzon und Mindanao, die ich vorläufig als Varietät betrachte.

Var. β. Differt foliis tenerribus, habitu *U. verticillati.*

Area geogr. Ins. Sund. Ins. Philipp.: BATAN ISLANDS, Batan, Mount Iraya, *Bur. Sci. 3828 Fénix.* LUZON, Ilocos Norte Province, Mount Palimlim, *Bur. Sci. 33248 Ramos:* Abra Province, Mount Posuey, *Bur. Sci. 27000 Ramos,* β: Benguet Subprovince, Mount Tonglon (Santo Tomas) *Topping 1202, Elmer 6619 p.p., Bur. Sci. 5352 Ramos;* Mount Ugo, *Bur. Sci. 5815 Ramos:* Bataan Province, Mount Mariveles, *Whitford 166, Topping 359, Merrill 3219:* Laguna Province, Mount Banahao, *Copeland s.n.* MINDANAO, Agusan Province, Mount Urdaneta, *Elmer 14080,* β: Misamis Province, Mount Malindang, *For. Bur. 4620, 4655 Mearns & Hutchinson:* Lanao District, Camp Keithley, *Mrs. Clemens s. n.*

An bemoosten Bäumen in Höhen von 1,000–2,400 m.

UROSTACHYS ELMERI Hert. sp. nov.

Radix densiter fasciculata, long. 5 cm. Frons brunnea, viridis vel brunneo-viridis, ter-quater bipartita, primum probabiliter erecta, deinde pendula, long. 30–70 cm, lat. 2–4 cm foliis inclusis. Caulis rigidus, basi diam. 3 mm foliis exclusis. Flores ter-quater bipartiti, long. 5–20 cm, lat. 1.5 (–3) mm. Folia ± octofaria, densa, erecto-patentia, rarius subhorizontaliter patentia vel reflexa, coriacea, lanceolata, acuta, nitida, infra subcarinata, marginibus subrevolutis, 3–5 x 15–20 mm. Sporophylla densissima, lanceolata, erecto-patentia seu appressa, ± quadrifaria, subcarinata, sporangia subtegentia, 1 x 2–3 mm. Sporangia lat. vix 1 mm. Planta epiphytica proxime affinis *U. phlegmariae* et *U. banayanico* a quibus imprimis foliis densis coriaceis majoribus differt.

Area geogr. Ins. Philipp.: Herb. Willdenow *"Lycopodium mirabile".* LUZON, Benguet Subprovince, Twin Peaks, *Elmer 6411:* Tayabas Province, *Bur. Sci. 5805 Savella;* Mahaihai *Wichura 1932:* Rizal Province, Tanay, *Merrill 2313, Bur. Sci. 15168 Reillo.* MINDORO, Baco, *Merrill 1246.* CULION, *Merrill 497.* PALAWAN, *Bur. Sci. 372 Bermejos, For. Bur. 3906 Curran.*

MINDANAO, Surigao Province, *Bolster 364:* Cotabato District, *Clemens:* Davao District, *Warburg 14202.* SIBUTU, *Merrill 5293.* An Felsen und Bäumen oftmals am Meeresstrande.

UROSTACHYS BANAYANICUS Hert. sp. nov.

Radix fasciculata, 5 cm long. Frons griseo- vel brunneo-viridis, sexies-pluries bipartita, pendula, long. 100 cm et ultra, lat. 12–16 mm et ultra, foliis inclusis. Caulis subrigidus, postea flaccidus, basi diam. 2–3 mm foliis exclusis. Flores flaccidi, pluries bipartiti, long. 10–20 cm, lat. 1.5–2.5 mm. Folia sparsa, non densa, ± 6 pro cm, axim non tegentia, ± sexfaria, erecto-patentia, rarius horizontaliter patentia, tenera, lanceolata, acuminata, bruta, rarius nitida, plana, marginibus subrevolutis, (1–) 2–3 x 8–10 (–12) mm. Sporophylla densissima, lanceolata, erecto-patentia, saepe incurvata, seu appressa, ± quadrifaria, subcarinata, sporangia subtegentia, 1 x 2–3 mm. Sporangia lat. vix 1 mm. Planta epiphytica proxima *U. phlegmariae* a quo imprimis foliis angustis differt.—Non rara est forma monstrosa perfoliata (*)—Variat foliis tenerrimis habitu *U. pinifolii* (* *).

LUZON, Abra Province, *Bur. Sci. 7258 Ramos p.p.:* Bataan Province, Mount Mariveles, *Whitford 167*, Elmer 6826, Topping 845:* Laguna Province, Mount Banahao, *Calvin 325, For. Bur. 8003 Curran & Merritt, Bur. Sci. 879 Foxworthy.* MINDORO, Mount Halcon, *Merrill 6034, 6035.* PANAY, Antique Province. Culasi, *Bur. Sci. 32433 McGregor*.* NEGROS, Cuernos Mountains, *Elmer 9498.* CAMIGUIN DE MISAMIS, *Bur. Sci. 14840 Ramos.* MINDANAO, Davao District, *Copeland 1144*, 1450, Warburg 14201:* Agusan Province, Mount Urdaneta, *Elmer 13858**.* An Waldbäumen in Höhen von 1,000–2,000 m.

UROSTACHYS PHLEGMARIA (Linn.) Hert. comb. nov.

Lycopodium phlegmaria Linn. Sp. Pl. (1753) 1101, ed. 2 (1763) 1564.

Area geogr. Regn. paleotrop. Ins. Philipp.: *Cuming 1997 "Selaginella circinalis," 2002, 2007* Herb. Delessert. LUZON, Cagayan Province, Lallo, *For. Bur. 24849 Barros:* Tayabas Province, Mahaihai, *Brackenridge* in Wilkes U. S. Explor. Exped. 16 (1854) 326 ε *gracilescens*; Kabibihan, *Bur. Sci. 13001 Ramos:* Rizal Province, *Barthe:* Laguna Province, Siniloan, *Warburg 12938, 14022;* Mount Maquiling, *For. Bur. 26033 Mabesa;* Malinao, *Baker 3723:* Sorsogon Province, Mount Bulusan, *Elmer 15255.* POLILLO, *Bur. Sci. 9239 Robinson.* MIN-

DORO, Baco, *Merrill 885.* LEYTE, Dagami, *Wenzel.* PALAWAN, *For. Bur. 518 Curran.* SIARGAO, *Bur. Sci. 34985 Ramos & Pascasio.* MINDANAO, Agusan Province, *Weber 1179:* Lanao District, Lake Lanao, *Clemens.* An Bäumen in mittleren Höhen.

Nom. vulgare: Tagigongai (Neg.); tagalailai (Tag.).

UROSTACHYS SALVINIOIDES Hert. sp. nov.

Radix fasciculata, pluries bipartita, long. 3 cm. Frons griseo- v. luteo- v. brunneo-viridis, sexies s. magis bipartita, pendula, flaccida, long. 100 cm et ultra, lat. 8–12, rariter usque ad 15 cm foliis inclusis. Caulis flaccidus, basi diam. usque ad 1 mm foliis exclusis. Flores flaccidi, pluries bipartiti, long. 10–20 cm, lat. 1–1.5 mm. Folia subremota, ± sexfaria, 6–8 pro cm, axim non tegentia, tenera, horizontaliter s. erecto-patentia, ovata v. subcordata, acuminata, bruta v. nitida, plana, nervo vix prominente, 2–6 x 3–6 mm. Sporophylla conferta, ovato-lanceolata, erecto-incurvato-patentia s. appressa, ± quadrifaria, subcarinata, sporangia subtegentia, 1 x 2 mm. Spororangia lat. vix 1 mm. —Differt ab. *U. phlegmaria* foliis tenerrimis, horizontaliter patentibus, remotis, ovatis, paullummodo longioribus quam latis, ab. *U. nummulariifolio* et *U. Delbrückii* imprimis foliis acutiusculis.

Variat foliorum textura firmiore et teneriore.

Area geogr. Ins. Philipp. LUZON, Ifugao Subprovince, Mount Polis, *Phil. Pl. 1565 McGregor:* Apayao Subprovince, Mount Sulu, *Bur. Sci. 28379 Fénix:* Cagayan Province, *For. Bur. 16720 Curran:* Abra Province, *Bur. Sci. 7258 Ramos p.p.:* Bataan Province, Mount Mariveles, *Williams 786, For. Bur. 2101 Borden:* Laguna Province, San Antonio, *For. Bur. 9530, 13179 Curran, Bur. Sci. 20610 Ramos.* POLILLO, *Bur. Sci. 10292 McGregor.* CATANDUANES, *Bur. Sci. 30445 Ramos.* MINDORO, Binabay River, *Merrill 6036;* Baco River, *McGregor 294.* SAMAR, Catubig River, *Bur. Sci. 24396 Ramos.* PANAY, Capiz Province, *Bur. Sci. 30686, 31213 Ramos & Edaño, 35319 Martelino & Edaño.* LEYTE, Dagami, *Wenzel 274.* NEGROS, Mount Silay, *Whitford & Everett 1502;* Cuernos Mountains, *Elmer 9499.* MINDANAO, Zamboanga District, San Ramon, *Copeland 1450, Merrill 8298:* Lanao District, Camp Keithley, *Clemens:* Cotabato District, *Warburg 14198:* Davao District, Mount Apo, *Copeland 1274, Williams 2462, Elmer 10665.* JOLO, *Clemens 9368.* An Bäumen in mittleren und höheren Regionen.

Nom. vulgare: Nito-nito (Neg.).

Sectio NUMMULARIIFOLIURUS Hert. sect. nov.

Series NUMMULARIIFOLIA Hert. op. cit.

UROSTACHYS DELBRÜCKII Hert. sp. nov.

Radix fasciculata, pluries bipartita, long. 2 cm. Frons luteo-brunneo viridis, quinquies bipartita, pendula, flaccida, long. 35 cm, lat. 8–15 mm foliis inclusis. Caulis basi diam. 1 mm foliis exclusis. Flores simplices s. bipartiti, long. 10 cm, lat. 3–5 mm sporophyllis inclusis, subquadrifarii. Folia subconferta, quadrifaria-sexfaria, 6 pro cm, axim fere tegentia, erecto-patentia, subovata, obtusa s. subacuminata, subnitida, plana, marginibus subrevolutis, nervo infra prominente, subcoriacea, 3–4 x 6–8 mm. Sporophylla conferta, ± quadrifaria, lanceolata, acuminata, carinata, erecto-patentia, apice subrevoluta, sporangia subtegentia, 1.5 x 2.5 mm. Sporangia lat. ± 1 mm. Planta intermediaria inter *U. nummulariifolium* et species quasdam *Phlegmariuri* sectionis.

Area geogr. Ins. Philipp. MINDANAO, Misamis Province, Mount Malindang, *For. Bur. 4654 Mearns & Hutchinson.*

Genus **LYCOPODIUM** (Linn.) Hert. in Beih. Bot. Centralbl. (1922).

Lycopodium subgen. II–VI Hert. in Engl. Bot. Jahrb. 43 (1909) Beih. 98: 29.

Subgenus **Acrostachys** Hert. subgen. nov. Subgen. II–V Hert. l.c.

Sectio EULYCOPODIUM Hert. sect. nov. Subgen. II–III Hert. l.c.

LYCOPODIUM CLAVATUM Linn. Sp. Pl. (1753) 1100, ed. 2 (1763) 1564, var. **WALLICHIANUM** Spring Monog. Lycop. 1 (1842) 90.

Area geogr. Regn. subarct., temp., subtrop., trop. Ins. Philipp.: LUZON, Benguet Subprovince, *Callery 69,* Sablan, *Elmer 6257;* Baguio, *For. Bur. 964 Barnes, Topping 203;* Mount Santo Tomas, *For. Bur. 5002 Curran, 11096 Whitford, Merrill Phil. Pl. 964, Bur. Sci. 5351 Ramos;* Mount Ugo, *Bur. Sci. 5851 Ramos;* Pauai, *Topping 1144, Copeland 1946, Clemens 9114, Bur. Sci. 31903 Santos, 8445 McGregor:* Bontoc Subprovince, *Vanoverbergh 370:* Laguna Province, Mount Banahao, *Bur. Sci. 9844 Robinson.* An Felsenpartien oftmals in Graslandschaften, etc., in Höhen von 1,200–2,400 m.

LYCOPODIUM COMPLANATUM Linn. Sp. Pl. (1753) 1104, ed. 2 (1763) 1567.

Lycopodium anceps Wallroth; Schol. in Linnaea 14 (1840) 674, *β adpressifolium* Spring Monog. Lycopod. 1 (1842) 102. nebst forma *monostachya* (*).

Area geogr. Regn. subarct., temp., subtrop., trop. Ins. Philipp.: LUZON, Benguet Subprovince, Pauai, *Bur. Sci. 4232, 4465*

Mearns, 31902 Santos; Mount Tabiao, *Copeland 1813;* Mount Pulog, *For. Bur. 16324 Curran, Merritt, & Zschokke,*;* Baguio, *Elmer 6522;* Mount Tonglon (Santo Tomas), *Merrill Phil. Pl. 963, For. Bur. 5001 Curran, 11095 Whitford:* Bontoc Subprovince, Bauco, *Vanoverbergh 989:* Laguna Province, Mount Banahao, *For. Bur. 7982 Curran & Merritt, Bur. Sci. 2398 Foxworthy.* MINDORO, Mount Halcon, *Merrill 6033.* An freien Felsenabhängen, etc., in den höheren Gebirgen, in höhen von 1,650–2,400 m.

Nom. vulgare: Yoyokau (Ig.).

LYCOPODIUM SCARIOSUM Forst. Prodr. (1786) 86.

Area geogr. Australia, Nov. Zealand. Ins. Philipp.: MINDANAO, Davao District, Mount Apo, *Copeland 1041, 1451, Elmer 11384, DeVore & Hoover 339 p.p., 523 p.p.* In freien offnen Landschaften, auf dem Gebirgsrücken des Berges Apo, Höhe ungefähr 2,800 m.

Subgenus **Cernuostachys** Hert. op. cit.

LYCOPODIUM CERNUUM Linn. Sp. Pl. (1753) 1103 (Indiis) et ed. 2 (1763) 1566 [nebst γ *crassifolium* Spring Monog. Lycopod. 1 (1842) 80].

Area geogr. Regn. circumtrop. Ins. Philipp.: *Cuming 2020, 2335, Labillardière,* herb. Webb, herb. Paris. BATAN ISLANDS, Batan, *Bur. Sci. 3830 Fénix.* LUZON, *Jagor 760, 771:* Cagayan Province, Claveria, *Bur. Sci. 7568 Ramos:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 19673 McGregor:* Benguet Subprovince, *For. Bur. 965 Barnes;* Sablan, *Bur. Sci. 12611 Fénix;* Mount Tonglon, *Bur. Sci. 5302, 5366 Ramos;* Pauai, *Bur. Sci. 31922 Santos;* Baguio, *Bur. Sci. 2475, 2758, 2840 Mearns, For. Bur. 4906 Curran, 972 Barnes, Topping 184, 3018, Elmer 5781:* Bontoc Subprovince, Bauco, *Vanoverbergh 51:* Lepanto Subprovince, Mount Malaya, *For. Bur. 16571 Darling;* Cervantes, *Bona 40:* Tayabas Province, *Bur. Sci. 26633, 28656 Ramos & Edaño, 9458 Robinson:* Laguna Province, *For. Bur. 19121 Tamesis, 9541 Curran, Bur. Sci. 15042 Ramos, Merrill Phil. Pl. 644, 957, Elmer 17874, Holman 32, 146, Baker 2348:* Bataan Province, Mount Mariveles, *For. Bur. 2096 Borden:* Zambales Province, Mount Pinatubo, *Bur. Sci. 2559, 2583 Foxworthy;* Nueva Vizcaya Province, Dupax-Carranglang Trail, *Bur. Sci. 14270 McGregor;* Imugan, *Bur. Sci. 14405 McGregor;* Santa Fé, *Bur. Sci. 8276 Ramos;* Caraballo Mountains, *Merrill 223:* Camarines Province, *For. Bur. 21684 Miranda, 27412 Alambra, Bur. Sci. 33624 Ramos & Edaño:* Albay Province, Mount Mayon, *Bur. Sci. 6494*

Robinson: Sorsogon Province, Mount Kililibong, *Bur. Sci. 23326 Ramos.* POLILLO, *Bur. Sci. 9094 Robinson, 10286 McGregor.* MINDORO, Bacubay, *For. Bur. 12106 Merritt;* Mount Halcon, *Merrill 6029, 6030* γ, *For. Bur. 4403 Merritt,* γ; Baco River, *McGregor 266, Merrill 4067.* PANAY, *Bur. Sci. 35703 Martelino & Edaño, 32298 McGregor.* LEYTE, Dagami, *Wenzel 75, 764, 1023.* NEGROS, Canlaon Volcano, *Merrill 6967, 8029* γ; Mount Silay, *Whitford & Everett 1529, For. Bur. 6226 Everett.* BUCAS GRANDE, *Bur. Sci. 35038 Ramos & Pascasio.* CAMIGUIN DE MISAMIS, *Bur. Sci. 14784 Ramos.* MINDANAO, Surigao Province, *Wenzel 1874, Bolster 304, Ballen 157;* Agusan Province, *For. Bur. 24507 Sabino, Elmer 14141:* Davao District, Mount Apo, *Elmer 10554, De Vore & Hoover 339 p.p., 523 p.p.* γ, *Copeland 1490* γ, *1038* γ; Lanao District, Camp Keithley, *Clemens 43, For. Bur. 20278 Miranda:* Misamis Province, Mount Malindang, *For. Bur. 4784 Mearns & Hutchinson:* Zamboanga District, San Ramon, *Copeland 1633, 1633a, 1768.* BASILAN, *Bur. Sci. 16229 Reillo.* An Felsenpartien und freien Abhängen, etc., meist in mittleren und höheren Regionen, selten in Meereshöhe, aufsteigend bis zu 2,800 m. Höhe.

Nom. vulgare: Duyoko (Ig.); kolo-kolo (Bon.); kuyo-kuyo (Bis.); lamong-babae (Tag.); lovi-lovi (Bik.); yakyakan (Ig.) yuyukau (Ig.).

LYCOPODIUM CASUARINOIDES Spring Monog. Lycopod. 1 (1842) 94.

Area geogr. As. merid. - or., Ins. Sund., Ins. Philipp.: *Cuming 2346.* LUZON, Benguet Subprovince, Loo, *For. Bur. 10944 Curran;* Pauai, *Bur. Sci. 4231, 4233 Mearns, Clemens 9229;* Baguio, *Topping 160, Elmer 6376:* Bontoc Subprovince, *Vanoverbergh 369.* MINDORO, Mount Halcon, *Merrill 6032.* An freien Gebirgskämmen und Felsenvorsprüngen, in Höhen von 1,400–2,400 m.

Nom. vulgare: Kulut-kulut (Bon.).

LYCOPODIUM VOLUBILE Forst. Prodr. (1786) 86.

Area geogr. Reg. Monsun., Ins. Societ., Nov. Zealand., Ins. Philipp.: LUZON, Benguet Subprovince, Mount Pulog, *Merrill 6392;* Mount Tonglon (Santo Tomas), *Merrill 4826, Topping 1208, Elmer 6240, For. Bur. 11102 Whitford, 4895 Curran;* Pauai, *Topping 1111, Bur. Sci. 4230 Mearns.* MINDANAO, Misamis Province, Mount Malindang, *For. Bur. 4628 Mearns & Hutchinson.* In dichtem Gebüsch auf Bergrücken in den höheren Gebirgen, in Höhen von 2,000–2,600 m.

Subgenus **Lateristachys** Hert. op. cit.

LYCOPODIUM HALCONENSE Copel. in Philip. Journ. Sci. 2 (1907) Bot. 149.

Area geogr. Ins. Philipp. MINDORO, Mount Halcon, *Merrill 6031.* Auf freien Berglehnen, in Höhen von 2,400 m.

DRITTER TEIL

ÜBERBLICK ÜBER DIE GEOGRAPHISCHE VERBREITUNG DER ARTEN

Auf den Philippinen sind durch die vorliegende Arbeit 22 Lycopodiaceen und zwar 15 *Urostachys-* und 7 *Lycopodium-*Arten nachgewiesen worden. Wie überall in den Tropen überwiegen auch auf den Philippinen die *Urostachya* bedeutend über die *Lycopodia.* Unter den Urostachyen sind die aufrechten Geophyten (Sect. *Selaginurus*) durch 2 Arten vertreten, während die hängenden Epiphyten mit 13 Arten (Sect. *Tenuistachys* mit 1 Art, *Squarrosurus* und *Carinaturus* mit je 3, *Phlegmariurus* mit 5 Arten, *Nummulariifoliurus* mit 1 Art) den Hauptbestandteil der Lycopodiaceenflora ausmachen. Unter den Lycopodien sind 3 kriechende *Eulycopodia,* ferner die 3 Hauptarten der tropischen Sect. *Cernuostachys* (1 Kriechstrauch, 2 Kletterer) sowie schliesslich 1 Art der interessanten Sect. *Lateralistachys* (Kriecher), deren übrige Arten auf das australe Florenreich beschränkt sind, vertreten.

Von den 22 philippinischen Lycopodiaceen sind 11 Arten, also die Hälfte, auch ausserhalb der Philippinen verbreitet, und zwar kommen 5 *Urostachya* und 6 *Lycopodia* auch ausserhalb des Gebietes vor, mithin fast alle Lycopodien, dagegen vehältnismässig wenige Urostachyen. Bis in das subarktische Gebiet hinein erstreckt sich das Areal von 2 Arten: *U. serratus* und *L. complanatum;* ersteres ist auf Ostasien beschränkt, letzteres ist über vier Erdteile verbreitet. Beide Arten kommen in unserem Gebiet nur auf den höchsten Gebirgen vor, während sie polwärts auch in der Ebene zu finden sind. Circumtropikal verbreitet sind 2 Arten: *L. clavatum* und *L. cernuum;* ersteres kann als Hochgebirgsform der in den subarktischen und temperierten Gebieten auch in der Ebene vorkommenden Hauptart aufgefasst werden, letzteres ist eine überall in den Tropen in allen Höhenlagen (im Hochgebirge in der Form γ *crassifolium*) häufige Species. Im palaeotropischen und australen Florenreich sind 3 Arten verbreitet: *U. carinatus* (As., Austral.), *U. phleg-*

Verbreitung der Philippinischen Lycopodien.

	Ausserhalb der Philippinen.					Auf den Philippinen.																			
	Reg. subarct. et temp.	Reg. subtrop. et trop.				Batsan.	Babuyan (Camiguin).	Luzon.	Polillo.	Catanduanes.	Mindoro.	Samar.	Cullon.	Panay.	Leyte.	Palawan.	Negros.	Siargao.	Bucas Grande.	Mindanao.	Basilan.	Jolo.	Sibutu.
		Reg. palaeotrop.		Reg. neotrop.	Reg. austral.																			
		As.	Afr.																					
Urostochys.																								
Ia 1. *minimus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	
Ia 2. *serratus*	+	+	—	—	—	—	—	+	—	—	+	—	—	—	—	—	+	—	—	+	—	—	—	
Ib 3. *verticillatus* γ & δ	+	—	—	—	—	—	—	+	—	—	+	—	—	—	—	—	—	—	—	+	—	—	—	
Ic 4. *squarrosus*	—	+	+	—	—	—	+	+	—	—	+	—	—	—	+	—	—	+	—	+	—	—	—	
Ic 5. *Magnusianus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	
Ic 6. *Whitfordi*	—	—	—	—	—	—	—	—	—	—	+	—	—	—	+	—	—	—	—	+	—	—	—	
7. *Toppingi*	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
8. *carinatus*	—	+	—	—	+	—	—	+	+	—	—	—	—	—	—	—	—	—	—	+	—	—	—	
9. *Merrilli*	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
IIa 10. *pinifolius*	—	+	—	—	—	+	—	+	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	
IIa 11. *Elmeri*	—	—	—	—	—	—	—	+	—	—	+	—	+	—	—	+	—	—	—	+	—	—	+	
IIa 12. *banayanicus*	—	—	—	—	—	—	+	+	—	—	+	—	—	+	—	—	+	—	—	+	—	—	—	
IIa 13. *phlegmaria*	—	+	+	—	(+)	—	—	+	+	—	+	—	—	—	+	+	—	+	—	+	—	—	—	
IIa 14. *salvinioides*	—	—	—	—	—	—	—	+	+	+	+	+	—	+	+	—	—	—	+	+	—	—	—	
IIb 15. *Delbrückii*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	
Lycopodium.																								
Ia 1. *clavatum* ϵ	(+)	+	+	+	+	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Ia 2. *complanatum*	+	+	+	+	—	—	—	+	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	
Ia 3. *scariosum*	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	

| | | |

maria (As., Afr., Austral.), *L. volubile* (As., Austral.). Auf das palaeotropische Florenreich beschränkt sind 3 Arten: *U. squarrosus* (As., Afr.), *U. pinifolius* (As.), *L. casuarinoides* As.). Dem australen Florenreich schliesslich gehört 1 Art an: *L. scariosum*, das im Gebiet auf dem höchsten Gipfel von Mindanao vorkommt. Von den 11 Endemismen, die sich aus 10 *Urostachys*-arten und 1 *Lycopodium* zusammensetzen, hat *U. minimus* (Gruppe des *U. selago*) seine nächsten verwandten in temperierten-subarktischen Gebieten bezw. auf den Hochgebirgen der Tropen, *L. halconense* (Gruppe des *L. laterale*) im australen Florenreich; ersteres kommt auf dem höchsten Gipfel von Mindanao, letzteres im Hochgebirge von Mindoro vor. Die übrigen 9 Endemismen haben ihre Verwandten in den umliegenden tropischen Gebieten wohnen. Es sind sämtlich hängende Epiphyten, die demnach den Hauptanteil auch unter den Endemismen ausmachen.

Die Lycopodiaceen der Philippinen zerfallen also in:

Drei Arten, die oder deren Verwandte bis in das subarktische Gebiet hinein verbreitet sind (die Geophyten *U. minimus, U. serratus, L. complanatum*).

Zwei circumtropikal verbreitete Arten (die Geophyten *L. clavatum* und L. *cernuum*).

Zwei Arten, die oder deren Verwandte im australen Florenreich zu Hause sind (die Geophyten *L. scariosum* und *L. halconense*).

Fünfzehn palaeotropische Arten, die zum kleinsten Teil auch im australen Florenreich verbreitet sind (alle epiphytischen *Urostachya* und die 2 kletternden *Lycopodia*).

Es sind im Gebiet der Philippinen bisher auf 18 Inseln Lycopodiaceen gefunden worden.

Die auch ausserhalb des Gebietes vorkommenden Arten.

	Inseln.
Urostachys serratus	4
Urostachys squarrosus	6
Urostachys carinatus	3
Urostachys pinifolius	3
Urostachys phlegmaria	7
Lycopodium clavatum ϵ	1
Lycopodium complanatum	2
Lycopodium scariosum	1
Lycopodium cernuum	11
Lycopodium casuarinoides	2
Lycopodium volubile	2
Sa.	42

Die endemischen Arten.

	Inseln.
Urostachys minimus	1
Urostachys verticillatus γ & δ	3
Urostachys Magnusianus	1
Urostachys Whitfordi	5
Urostachys Toppingi	1
Urostachys Merrilli	1
Urostachys Elmeri	6
Urostachys banayanicus	6
Urostachys salvinioides	10
Urostachys Delbrückii	1
Lycopodium halconense	1
Sa.	36

Am weitesten über das Inselreich verbreitet ist demnach von den ausserhalb des Gebietes vorkommenden Arten *L. cernuum* (auf 11 Inseln gefunden) und von den endemischen Arten *U. salvinioides* (auf 10 Inseln gefunden). Es folgen von den auch ausserhalb des Gebietes vorkommenden Arten: *U. phlegmaria* (auf 7 Inseln gefunden), *U. squarrosus* (6), *U. serratus* (4), *U. carinatus* und *U. pinifolius* (je 3), *L. complanatum, L. casuarinoides* und *L. volubile* (je 2), *L. clavatum* ε und *L. scariosum* (je 1); von den Endemismen: *U. Elmeri* und *banayanicus* (je 6), *Whitfordi* (5), *verticillatus* γ & δ (3), *minimus, Magnusianus, Toppingi, Merrilli, Delbrückii,* und *L. halconense* (je 1). In ihrer Gesamtheit sind also die endemischen Arten ähnlich über das Inselreich verbreitet wie die nicht endemischen, dagegen zeigt auch hier wieder die Gattung *Urostachys* eine weit grössere Verbreitung als die Gattung *Lycopodium.*

Alle Lycopodiaceen sind Gebirgspflanzen; nur wenige Arten gehen bis zum Meeresniveau hinab, so vor allem *U. squarrosus, U. salvinioides, U. Elmeri,* und *L. cernuum.* Infolgedessen sind die Hochgebirge der 3 grossen Inseln besonders reich an Lycopodiaceen. Es beherbergen:

	Arten.
Mindanao und Luzon, je	16
Mindoro	12
Panay und Negros, je	5
Polillo	4
Camiguin, Leyte, and Palawan, je	3
Batan	2
Die übrigen Inseln, je	1

Auf Mindanao beschränkt sind 4 Arten (3 endemische: *U. minimum, U. Magnusianus,* und *U. Delbrückii,* sowie 1 Art die sonst nur im australen Florenreich vorkommt, *L. scariosum*).

Auf Luzon beschränkt sind 3 Arten (2 endemische: *U. Toppingi, U. Merrilli,* ferner 1 Hochgebirgsart der Tropen, *L. clavatum* ϵ).

Auf Mindoro beschränkt ist die einer australischen Untergattung angehörende Art, *L. halconense.*

Wichtige Zentren sind:

Mindanao: Davao Distr., Todaya (Mount Apo) und Misamis Prov., Mount Malindang, 2,000–3,200 m, mit den 11 Arten: *U. minimus, serratus, verticillatus* γ *&* δ*, squarrosus, pinifolius, banayanicus, salvinioides, Delbrückii, L. scariosum, cernuum, volubile.*

Luzon,[1] Mountain Prov., Benguet Subprov., Mount Tonglon (Mount Sto. Tomas), Pauai, etc., 2,000–2,400 m, mit den 8 Arten: *U. serratus,* **Merrilli,** *pinifolius, L.* **clavatum, complanatum,** *cernuum,* **casuarinoides,** *volubile.*

Mindoro,[1] Mount Halcon, 2,000–2,700 m, mit den 8 Arten: *U. serratus, verticillatus* γ *&* δ*, squarrosus, banayanicus, L.* **complanatum,** *cernuum,* **casuarinoides, halconense.**

An diesen 3 Standorten kommen also insgesamt 16 Arten vor, von denen ein grosser Teil—mit Ausnahme besonders der oben genannten 4 bis zum Meere herabgehenden Arten *U. squarrosus, U. salvinioides, U. Elmeri,* und *L. cernuum*—auf den 3 Hauptinseln beschränkt ist. Die 6 Arten: *U. Magnusianus, U. Whitfordi, U. Toppingi, U. carinatus, U. Elmeri, U. phlegmaria,* bevorzugen anscheinend mittlere und niedere Gebirgslagen. Die Mehrzahl dieser Arten kommt—ebenso wie die genannten 3 bis zum Meeresspiegel gehenden Arten—auch auf den kleineren Inseln vor.

[1] Die auf Mindanao nicht vorkommenden Arten sind fett gedruckt.

THE ANTISCORBUTIC VITAMINE IN SOME ORIENTAL FRUITS AND VEGETABLES [1]

By Hartley Embrey

Of the Union Medical College, Peking

FIVE PLATES

Less is known of the antiscorbutic vitamine than of the other vitamines. It is soluble in water, and for that reason is often called water-soluble C vitamine. It is also soluble in alcohol and acetone.

It is more unstable than the other vitamines and is destroyed by heat—gradually above 50°C. and rapidly above 80°C.(1) It is also affected by catalysis.(2) For instance, if half of a given quantity of raw milk be heated in a glass vessel and the other half in a copper vessel for the same length of time—for thirty minutes at 145°F.—the milk heated in the copper vessel will have lost much more of the antiscorbutic vitamine than the milk heated in the glass vessel.

This vitamine is very unstable in the presence of alkalies and is especially sensitive to oxidation. In fact, oxidation is apparently the preëminent factor leading to the destruction of water-soluble C vitamine.

If a diet be given containing an insufficient amount of this vitamine, scurvy develops. This disease can be cured by the addition to the diet of fresh fruits and vegetables, which are rich in the antiscorbutic vitamine.

This paper discusses some research work that was undertaken with the hope of extending our knowledge as to which tropical fruits and foods are valuable as sources of supply of the antiscorbutic vitamine.

None of the vitamines can be determined satisfactorily by chemical means. Their presence can be detected and their relative quantities estimated by feeding experiments only. The guinea pig is very susceptible to scurvy and, therefore, is the best experimental animal for this purpose. Fed on a diet com-

[1] From the laboratories of Union Medical College, Peking; and the Bureau of Science, Manila, Philippine Islands.

plete in all other respects, but lacking in this one essential, the guinea pig develops scurvy as early as the fifteenth day and death occurs, usually, on the nineteenth to the twenty-third day.

The clinical symptoms of scurvy in the guinea pig are the following: Preliminary loss of weight, swelling of wrist and knee joints, and occasionally hyperæmia of the gums with dullness of the lower incisors. Fractures of the long bones and general fragility are common. Post-mortem examination shows "hemorrhages found in the muscles, bone marrow, more frequently at the end of diaphyses, tooth pulp, costochondral junctions, and occasionally in the skin and lymph glands; enlargements of the ends of the long bones, especially the lower ends of the radius and ulna, the upper end of the tibia, and the costochondral junctions; and swollen lymph glands especially the inguinal and axillary."(3)

The following fruits and vegetables were tested at the Bureau of Science in Manila:

Chico, *Achras sapota* Linnæus.
Papaya, *Carica papaya* Linnæus.
Pomelo, *Citrus maxima* Merrill.
Guava, *Psidium guajava* Linnæus.
Lansones, *Lansium domesticum* Correa.
Banana, *Musa cavendishii* Lambert.
Banana flower bud.
Coconut, *Cocos nucifera* Linnæus.
Pepino or cucumber, *Cucumis sativas* Linnæus.
Kangkong leaves, *Ipomoea reptans* (Linnæus) Poiret.
Camote leaves, *Ipomoea batatas* (Linnæus) Poiret.

In addition to the fruits tested at the Bureau of Science in Manila, another fruit, the Chinese persimmon, *Diospyros kaki* Linnæus, was tested at the Union Medical College, in Peking, China.

Filipinos usually cook the camote and kangkong leaves and use them as greens. The banana-flower bud is boiled and used as a vegetable by most Filipinos, and to a limited degree by foreigners as well. In our feeding experiment, however, we cut the camote and kangkong leaves fine and gave them raw. In the case of the banana-flower bud and of the coconut, we expressed the juice and fed the undiluted juice, since the guinea pigs would not eat either the bud or the shredded coconut meat. The other foods were given in their raw, natural state.

For all the foods except persimmon, basal diet 1 was used, which consisted of:

	Per cent.
Whole oats	87
Rice bran (tikitiki)	10
Calcium chloride and disodium orthophosphate (equal weights)	3

The mixture of the above was given ad libitum; and, in addition, 30 cubic centimeters of whole cow's milk, previously boiled forty-five minutes, were given daily.

For the persimmon, basal diet 2 was used, which consisted of:

	Per cent.
Whole wheat	86
Yeast	2
Wheat bran	3
Butter	3
Calcium lactate	3
Sodium chloride	3

In the case of control guinea pig 3P, orange juice was added and the scurvy symptoms disappeared. Each animal was kept in a separate cage. Each morning all remains of the basal diet for the preceding day were removed, and a weighed amount of the food under examination was put in the cage. After a few hours, if the food was not eaten, it was fed to the guinea pig by hand; then the basal diet was given ad libitum. The guinea pigs were weighed twice a week, and a record of their weights was kept. Autopsy was performed on all guinea pigs that died before the termination of the experiment, to see whether the typical scurvy symptoms were present. The experiment in Manila was unfortunately of only nine weeks' duration, and it would be advisable to continue this work in order to determine the minimum amount of each food that must be administered daily to afford complete protection from scurvy. A group of control guinea pigs was given the basal diets without any fresh fruit or vegetable.

The Chinese persimmon was fed at the Union Medical College, Peking, and the experiment lasted twenty-four weeks.

CONCLUSIONS

1. All of the control guinea pigs died of acute scurvy in from nineteen to twenty-one days.

2. Of the foods examined, pomelo, cucumber, chico, and guava afforded the best protection from scurvy. In each case 10 grams of the food given daily were sufficient to protect the

animals from scurvy for a period of nine weeks. Where the charts show deaths on these diets after a few weeks, post-mortem examination showed the causative factor to be pneumonia.

3. Fifteen grams of banana each day gave protection from scurvy for a period of nine weeks.

4. The experiment with lansones had to be terminated after four weeks, because this fruit disappeared from the Manila markets, being no longer in season. A careful inspection of the lansones growth curves shows a steadily decreasing weight, so that 10 grams were evidently insufficient as a protection from scurvy.

5. Fifteen grams each of kangkong leaves and of camote leaves daily gave protection for a period of from seven to nine weeks.

ACKNOWLEDGMENT

Thanks are due to Miss Sylvia Sleeper, of Manila, and to Mr. Tsan Ching Wang, of Peking, who rendered valuable technical assistance.

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ILLUSTRATIONS

EXPLANATION OF CHARTS

The following charts show the identification numbers of the guinea pigs, the rates of growth, and the number of weeks' duration of experimental feeding.

The numbers above the growth curves are the identification numbers of the animals; the weights of the guinea pigs are shown by the figures on the axes of ordinates; the number of weeks of experimentation is indicated by the numbers on the axes of abscissæ. An arrowhead terminating the growth curve indicates the death of the animal in question. If the arrowhead is lacking, the animal was still living at the end of the experiment.

Guinea pigs 45, 46, 47, 48, 49, 50, 7, 13, 14, 15, 16, 21, 22, 23, 24, 34, 36, 37, 39, 41, 43, 44, 1P, 2P, 4P, 5P, 6P, 7P, and 8P died of scurvy. Deaths among the other pigs were due to pneumonia.

Basal diet 1 consisted of whole oats, 87 per cent; rice bran (tikitiki), 10 per cent; calcium carbonate ($CaCO_3$) and disodium orthophosphate (Na_2HPO_3), 3 per cent.

Basal diet 2 consisted of whole wheat, 86 per cent; yeast, 2 per cent; wheat bran, 3 per cent; butter, 3 per cent; calcium lactate, 3 per cent; sodium chloride, 3 per cent.

PLATE 1

FIG. 1. Guinea pigs 45 to 50. Diet, 30 cubic centimeters of whole milk boiled for forty-five minutes and basal diet 1.

2. Guinea pigs 17 to 20. Diet, 10 grams of raw chico and basal diet 1.

3. Guinea pigs 9 to 12. Diet, 10 grams of raw guava and basal diet 1.

PLATE 2

FIG. 4. Guinea pigs 5 to 8. Diet, 10 grams of raw lansones and basal diet 1.

5. Guinea pigs 25 to 28. Diet, 15 grams of raw banana and basal diet 1.

6. Guinea pigs 13 to 16. Diet, 10 cubic centimeters of banana flower bud juice and basal diet 1.

PLATE 3

FIG. 7. Guinea pigs 21 to 24. Diet, 10 cubic centimeters of fresh coconut juice squeezed from the white coconut meat and basal diet 1.

8. Guinea pigs 1 to 4. Diet, 10 grams of raw papaya and basal diet 1.

9. Guinea pigs 29 to 32. Diet, 10 grams of fresh raw pomelo and basal diet 1.

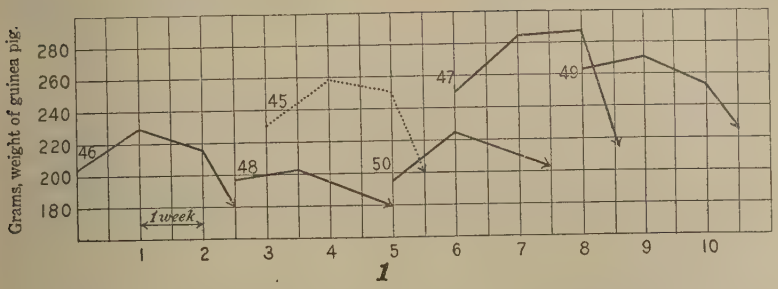
PLATE 4

10. Guinea pigs 33 to 36. Diet, 10 grams of raw pepino and basal diet 1.

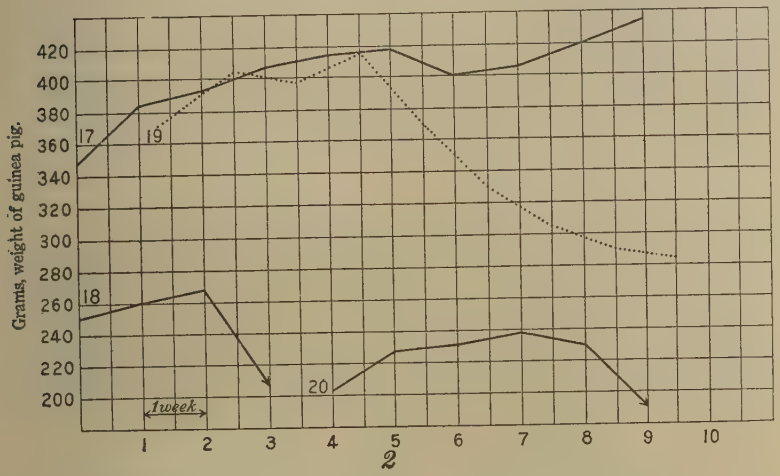
11. Guinea pigs 37 to 40. Diet 15 grams of raw camote leaves and basal diet 1.
12. Guinea pigs 41 to 44. Diet, 15 grams of raw kangkong leaves and basal diet 1.

PLATE 5

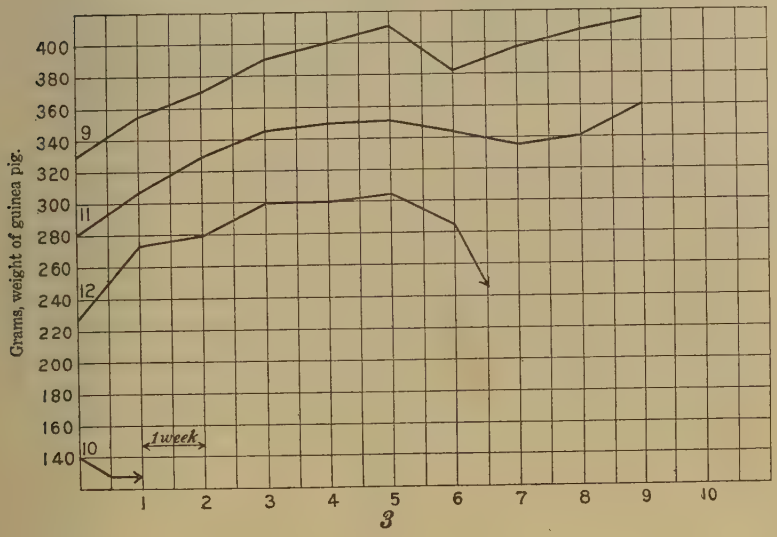
FIG. 13. Guinea pigs 1P to 4P. Diet, 300 cubic centimeters of whole milk previously boiled for forty-five minutes, ad libitum, and basal diet 2.
14. Guinea pigs 5P to 8P. Diet, 25 grams of fresh raw persimmon daily and basal diet 2, ad libitum.
15. Guinea pigs 9P to 12P. Diet, 30 grams of fresh raw persimmon daily and basal diet 2.


Grams, weight of guinea pig.
280
260
240
220
200
180
46
45
48
47
50
49
1 week
1 2 3 4 5 6 7 8 9 10

1

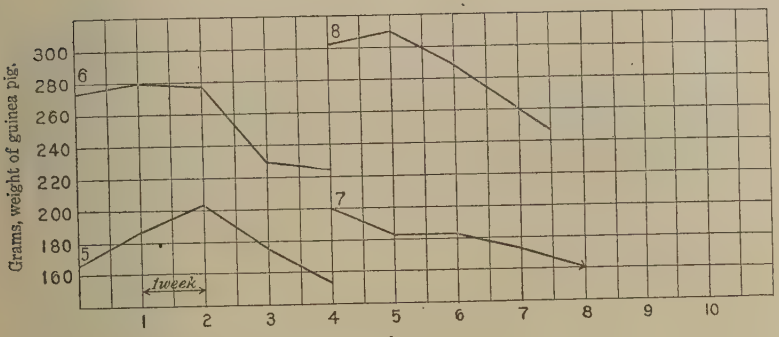

Grams, weight of guinea pig.
420
400
380
360
340
320
300
280
260
240
220
200
17
19
18
20
1 week
1 2 3 4 5 6 7 8 9 10

2

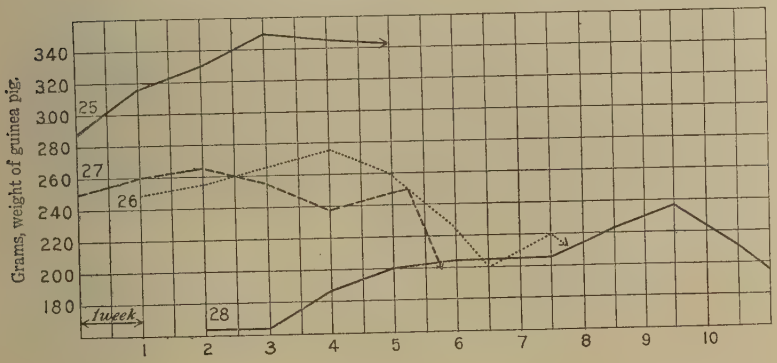

Grams, weight of guinea pig.
400
380
360
340
320
300
280
260
240
220
200
180
160
140
9
11
12
10
1 week
1 2 3 4 5 6 7 8 9 10

3

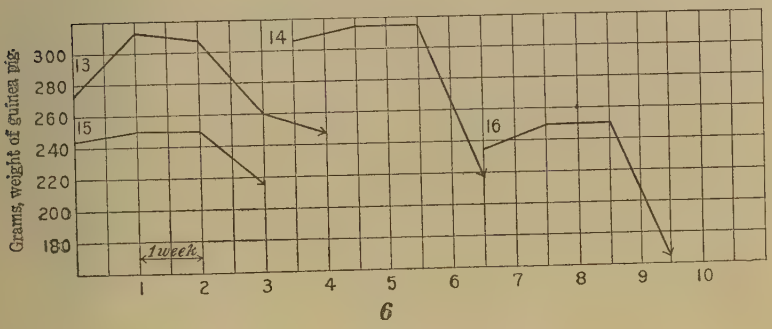
PLATE 1.


Grams, weight of guinea pig.
300
280
260
240
220
200
180
160
6
8
7
5
1week
1 2 3 4 5 6 7 8 9 10

4

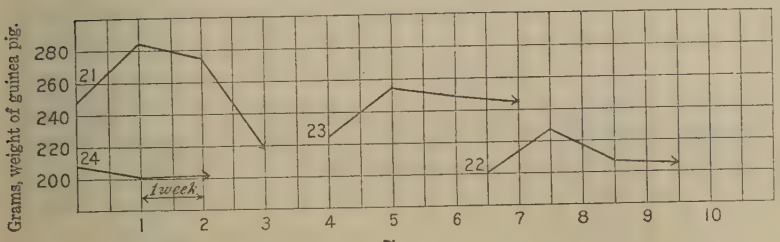

Grams, weight of guinea pig.
340
320
300
280
260
240
220
200
180
25
27
26
28
1week
1 2 3 4 5 6 7 8 9 10

5

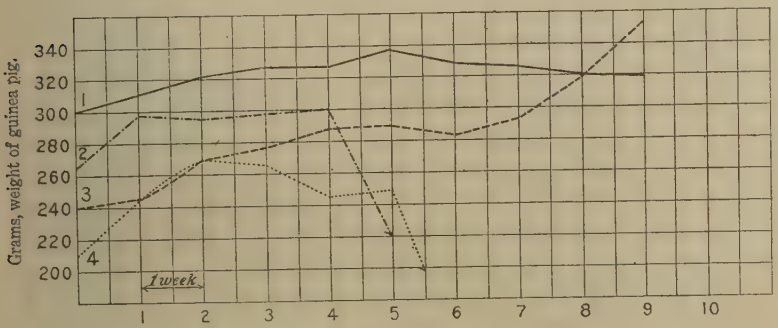

Grams, weight of guinea pig.
300
280
260
240
220
200
180
13
14
15
16
1week
1 2 3 4 5 6 7 8 9 10

6

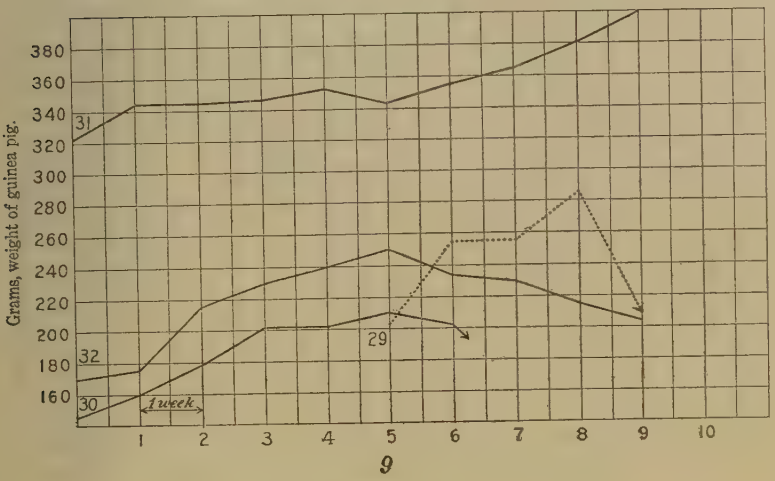
PLATE 2.


Grams, weight of guinea pig.
280
260
240
220
200
21
23
24
22
1 week
1
2
3
4
5
6
7
8
9
10

7


Grams, weight of guinea pig.
340
320
300
280
260
240
220
200
1
2
3
4
1 week
1
2
3
4
5
6
7
8
9
10

8


Grams, weight of guinea pig.
380
360
340
320
300
280
260
240
220
200
180
160
31
32
29
30
1 week
1
2
3
4
5
6
7
8
9
10

9

PLATE 3.

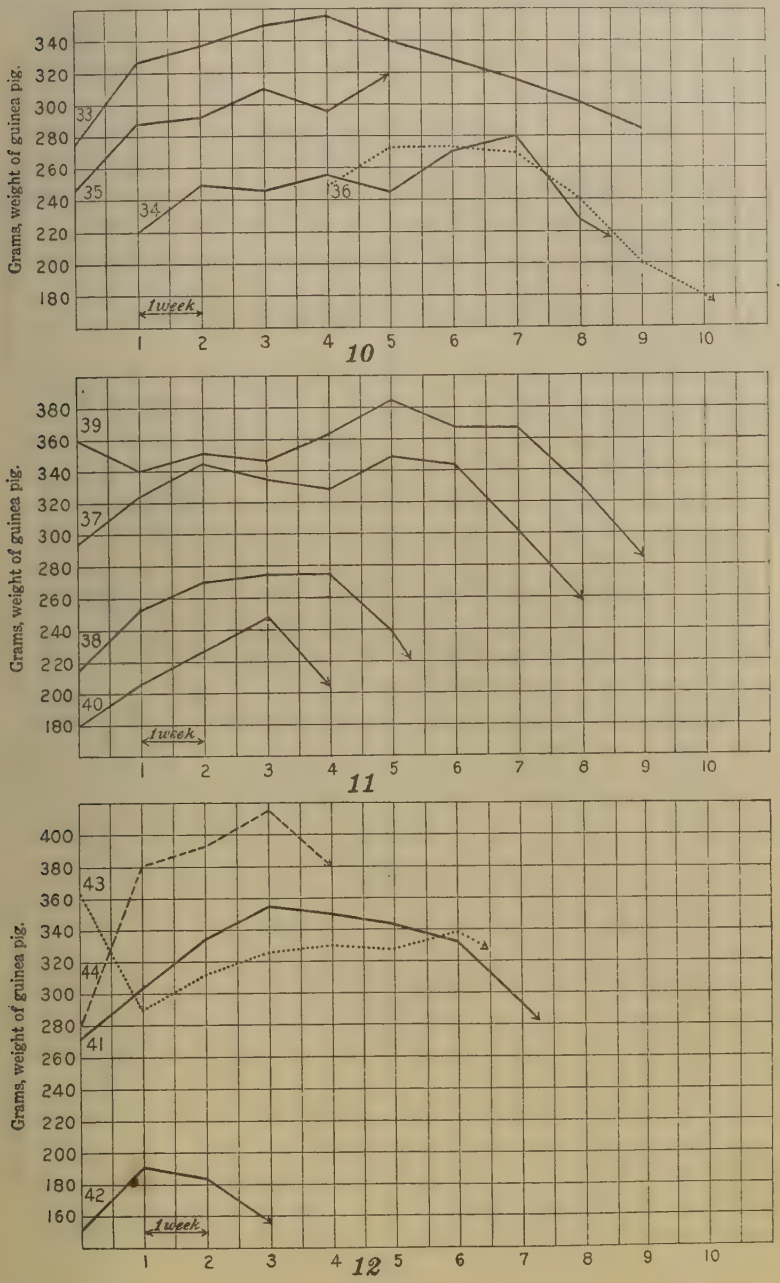
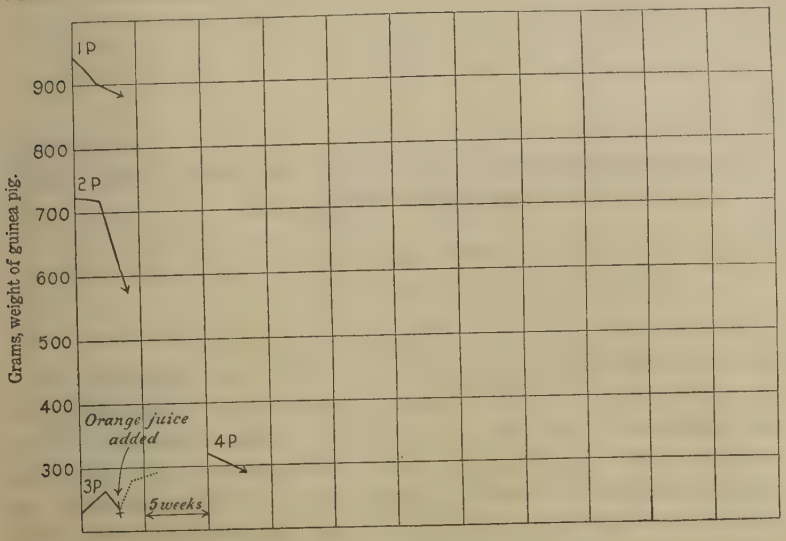

Grams, weight of guinea pig.
340
320
300
280
260
240
220
200
180
33
35
34
36
1week
1 2 3 4 5 6 7 8 9 10
10
Grams, weight of guinea pig.
380
360
340
320
300
280
260
240
220
200
180
39
37
38
40
1week
1 2 3 4 5 6 7 8 9 10
11
Grams, weight of guinea pig.
400
380
360
340
320
300
280
260
240
220
200
180
160
43
44
41
42
1week
1 2 3 4 5 6 7 8 9 10
12

PLATE 4.



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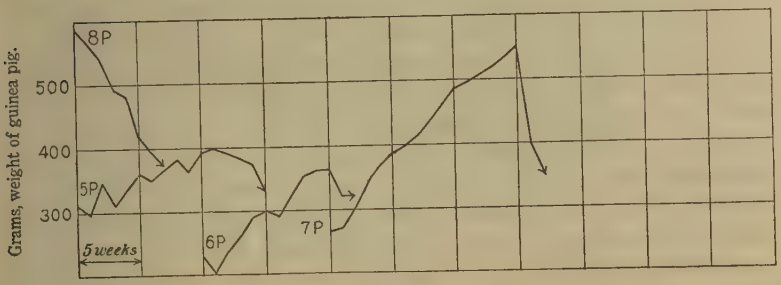
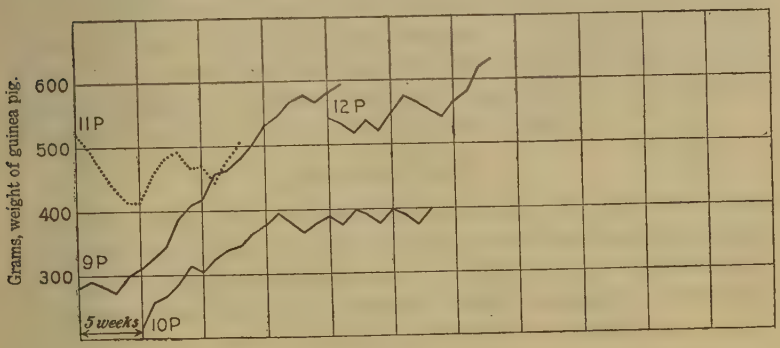


14



15

PLATE 5.

THE ELACATIDÆ OF THE PHILIPPINE ISLANDS AND ADJACENT REGIONS

By Edward A. Chapin

Of Washington, D. C.

ONE PLATE

The material upon which this paper is based was received at various times from Prof. Charles F. Baker, of the University of the Philippines. The family has been considered as composed of a single genus, since *Ababa* Casey was referred by Schaeffer (1917) to the family Cleridæ. Several species of the family Elacatidæ are known from the New World; two from Japan and one each from Batjan, Ceylon, and Borneo. The family is usually known under the name of Othniidæ, based on *Othnius* Leconte. *Elacatis* Pascoe has priority of a year.

The type genus, *Elacatis* Pascoe, was erected in 1860 as a member of the Melandryidæ to include a single species of doubtful affinities. The following year Leconte proposed a new family, the Othniidæ, for an American insect, *Othnius umbrosus*, a new genus and new species. A second species was mentioned at the time, but was described from memory only, the specimen being lost. Thus *O. umbrosus* Leconte is the type of *Othnius*. *Elacatis* Pascoe has been suppressed as a homonym of *Elacates* Cuvier, 1829, and *Othnius* Leconte has taken its place in most of the catalogues. This action was not taken by Kraatz or Lewis but was resumed by Borchmann.[1] A hasty examination of one of the American species revealed certain characters that may be considered of generic value; if such is the case, *Othnius* Leconte will stand for the New World forms.

ELACATIDÆ

Family characters.—Coleoptera genuina; Heteromera; head somewhat triangular, eyes large and prominent, lateral; labrum corneous, antennæ 11-segmented, arising from beneath the prominent supra-antennal crests, first segment moderately long and thick, second smaller, globular or cylindrical, third

[1] Schenkling, S., Col. Cat. Fam. Pars. 2, Othniidæ (1910).

luster. Thorax apparently as long as broad, very coarsely and evenly punctured, lateral margins with five denticles. Elytra evenly punctured, variegated with dark and light brown. Underparts dark, rather coarsely punctured. Legs dark.

Two subspecies can be recognized in the material at my disposal. Typical form: Elytra with three transverse dark bars and with a round dark spot in scutellar angle. Length, 3.5 millimeters.

Sandakan, Borneo (*Baker 11493*) and unnumbered specimens. Zamboanga, Mindanao, P. I. (*Baker 7283*).

Elacatis delusa subsp. **pantherina** subsp. nov.

Elytra with four more or less broken transverse dark bars (Plate 1, fig. 12), no separate spot in scutellar angle. Denticles of thorax slightly more prominent. Length, 3.5 millimeters.

Type.—A specimen, apparently a male, from Mount Limay, Bataan Province, Luzon, P. I. (*Baker 8292*). Paratypes from the same locality and from Mount Maquiling, Laguna Province, Luzon (*Baker 11941*). Also unnumbered specimens from the above localities. United States National Museum, No. 25055.

Genus **PARELACATIS** novum

Generic characters.—Elacatidæ with eyes produced posteriorly so as to overlap anterior angles of thorax; thorax with lateral margin more or less obsolete at anterior angles, complete at posterior angles, regular, without denticles. Second segment of antenna cylindrical, terminal segment of labial palpus rounded at apex, terminal segment of maxillary palpus only a little longer than broad (Plate 1, figs. 3, 4, 8, 9, 10).

Genotype, *Parelacatis bakeri* sp. nov.

There appears to be but one species in the material before me that can be referred to this genus.

Parelacatis bakeri sp. nov.

Head wide, convex, rather coarsely and distantly punctured, dark, with faint brassy luster. Supra-antennal crests arched, socket of antenna very large. Antennæ reaching to about middle of thorax, chestnut brown. Thorax much broader than long (13 : 20), convex, evenly and rather coarsely punctured, basal angles obtuse, surface with brassy luster, pubescence sparse on both head and thorax. Elytra rather suddenly rounded at tips, finely and rather densely punctured, dark with pale marking (Plate 1, fig. 13). Underparts black, rather more densely covered with hairs. Legs brown, the tibiæ and tarsi paler. Length, 2.5 to 3.5 millimeters.

Type.—A specimen, sex uncertain, from Basilan, P. I. (*Baker 13420*). Paratypes from the same locality and from Davao, Mindanao (*Baker 6659*); Iligan, Kolambugan, and Dapitan, Mindanao; Tangcolan, Bukidnon Province, Mindanao (*Baker 14665*); Mount Maquiling and Los Baños, Laguna Province, Luzon (*Baker 958*). United States National Museum, No. 25057.

ADDENDA

Since I sent this manuscript for publication, a paper by F. Borchmann [2] on the "Othniidæ" of the world has come to hand. Borchmann has prepared a very excellent study of the group, and if he has erred it has been on the side of conservatism. In his work a new species, *Othnius corporaali*, is described with the note that it may belong to a new genus. It appears to be congeneric with *Parelacatis bakeri* sp. nov., the type of my new genus *Parelacatis*. *Othnius acutedentatus*, a new species, is reported from Borneo and Luzon and would have been treated by me as a subspecies of *Elacatis delusa* Pascoe, so far as I am able to judge from the description. The same is true of his *Othnius foveicollis*. Borchmann [3] has described another species from northern Palawan under the name *Othnius ochripes*. It is unknown to me.

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[2] Arch. f. Naturg. 87 (1921) Abt. A, Heft 1, 191–215.
[3] Ent. Mitteil. 10 (1921) 198.

ILLUSTRATION

[From drawings by Chapin.]

PLATE 1

FIG. 1. *Elacatis delusa* subsp. *pantherina* subsp. nov., head.
2. *Elacatis delusa* subsp. *pantherina* subsp. nov., thorax from beneath.
3. *Parelacatis bakeri* sp. nov., head.
4. *Parelacatis bakeri* sp. nov., thorax from beneath.
5. *Elacatis delusa* subsp. *pantherina* subsp. nov., antenna.
6. *Elacatis delusa* subsp. *pantherina* subsp. nov., maxilla.
7. *Elacatis delusa* subsp. *pantherina* subsp. nov., labium with palpi.
8. *Parelacatis bakeri* sp. nov., labium with palpi.
9. *Parelacatis bakeri* sp. nov., maxilla.
10. *Parelacatis bakeri* sp. nov., antenna.
11. *Elacatis undulata* sp. nov., elytron.
12. *Elacatis delusa* subsp. *pantherina* subsp. nov., elytron.
13. *Parelacatis bakeri* sp. nov., elytron.

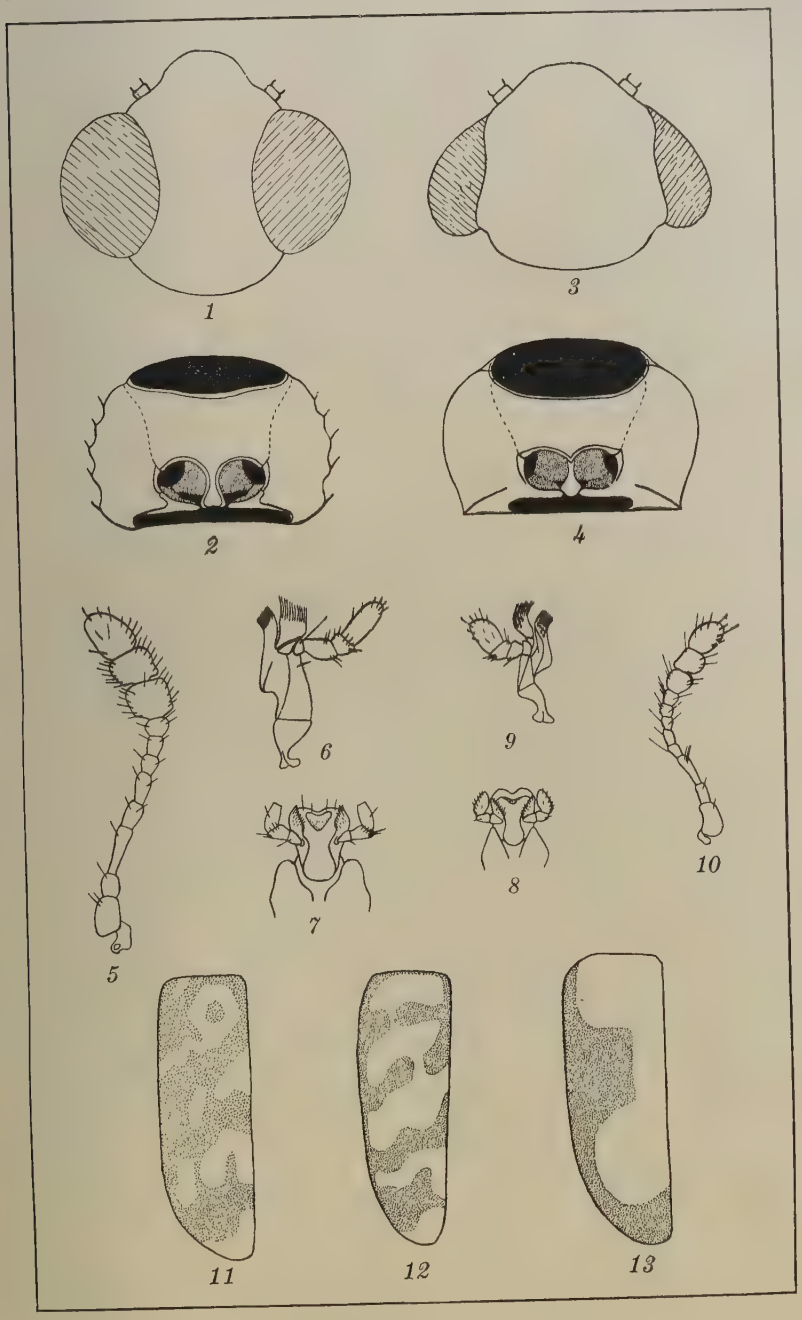

PLATE 1.

ZUR GEOGRAPHISCHEN VERBREITUNG DER CUCUJIDÆ (COLEOPTERA)[1]

ERSTER BEITRAG: LÆMOPHLŒINI

Von Fritz Kessel

Badenfurt, Süd-Brasilien

EINE TEXTFIGUR

Ueber den Cucujiden ist in den letzten Jahrzehnten intensiv gearbeitet worden. Besonders Grouvelle hat seit Mitte der siebziger Jahre des vorigen Jahrhunderts sehr viel publiziert; nächst ihm Sharp, Reitter, and andere. Leider fehlt es aber bisher fast durchweg an irgendwelchen zusammenfassenden Arbeiten über diese Familie beziehungsweise grössere Gruppen derselben. Das Material ist in den Zeitschriften fast aller Herrenländer verteilt, zerstreut sich auf grössere Zeiträume, sodass eine einigermassen umfassende Arbeit nicht unerhebliche Schwierigkeiten zu überwinden hat.

Von einzelnen Gruppen der Cucujiden hat, soweit mir bekannt, Grouvelle bis 1914 die Silvaninen und Ancistriinen zusammenhängend dargestellt. Ich nehme die Cucujidæ und Læmophlœini zunächst noch ohne Rücksicht auf meine früheren Ausführungen.[2]

Gerade die Zahl der bekannten Læmophlœinen-Arten ist riesig gewachsen. Der Katalog von Gemminger und Harold (1868) zählt 51 Arten; mir sind bis heute schon über 220 Arten bekannt geworden, und mit dieser Zahl dürfte auch noch nicht das letzte Wort gesprochen sein.

Trotz dieser starken Zunahme ist die Gruppe erst relativ spät (1899) von Sharp in Abteilungen zerstreut worden und zwar wohl nur unter hauptsächlicher Berücksichtigung der zentralamerikanischen Arten. Hier mögen zunächst einmal Angaben über die geographische Verbreitung folgen.

[1] The beetles of this important family, the Cucujidæ, commonly live under bark. Some of the species that live in stored food products are of great economic concern. The family is extensively represented in the Philippines where little is known of the native forms.—Editors.

[2] Archiv f. Naturgesch. 87 Heft 6, 25–35, im alten Umfange.

I. AFRIKA (KONTINENT)

1. *Læmophlœus ater* Ol., Nord-Afrika.
2. *Læmophlœus bolivari* Gr., Spanisch Guinea.
3. *Læmophlœus brunneus* Gr., Sierra Leone.
4. *Læmophlœus biskrensis* Gr., Nord-Afrika.
5. *Læmophlœus clarus* Gr., Cap der guten Hoffnung.
6. *Læmophlœus curtipennis* Gr., Spanisch Guinea.
7. *Læmophlœus elongatulus* Luc., Algier.
8. *Læmophlœus escalerae* Gr., Spanisch Guinea.
9. *Læmophlœus faneti* Grouv., West-Afrika.
10. *Læmophlœus mirus* Gr., Spanisch Guinea.
11. *Læmophlœus misellus* Gr., Kamerun.
12. *Læmophlœus mobilis* Gr., Sansibar.
13. *Læmophlœus nigricollis* Luc., Algier.
14. *Læmophlœus patens* Gr., Sansibar.
15. *Læmophlœus peculiaris* Gr., Spanisch Guinea.
16. *Læmophlœus peringueyi* Gr., Cap der guten Hoffnung.
17. *Læmophlœus perrisi* Gr., Algier.
18. *Læmophlœus perspicuus* Gr., Cap der guten Hoffnung.
19. *Læmophlœus plagiatus* Gr., Spanisch Guinea.
20. *Læmophlœus rufipes* Luc., Algier.
21. *Læmophlœus suberis* Luc., Algier.
22. *Læmophlœus subniger* Gr., Spanisch Guinea.

II. AUSTRALIEN (KONTINENT)

1. *Læmophlœus bistriatus* Gr.
2. *Læmophlœus contaminatus* Gr.
3. *Læmophlœus felix* Kess.
4. *Læmophlœus insignis* Gr.
5. *Læmophlœus juvencus* Kess.
6. *Læmophlœus leachi* Gr.
7. *Læmophlœus lepidus* Gr.
8. *Læmophlœus parvulus* Gr.
9. *Læmophlœus tasmanicus* Gr.
10. *Læmophlœus tuberculatus* Gr.

III. AUSTRALIEN (INSULAR)

1. *Læmophlœus beccarii* Gr.
2. *Læmophlœus brevis* Fairm.
3. *Læmophlœus dorsalis* Gr.
4. *Læmophlœus falcidens* Gr.
5. *Læmophlœus fauveli* Gr.
6. *Læmophlœus gestroi* Gr.
7. *Læmophlœus humeralis* Gr.
8. *Læmophlœus ignotus* Kess.
9. *Læmophlœus insularis* Kess.
10. *Læmophlœus integer* Gr.
11. *Læmophlœus neglectus* Gr.
12. *Læmophlœus patens* Gr.
13. *Læmophlœus* subgranulatus Gr.
14. *Læmophlœus tricostatus* Montrouz.

IV. AZOREN UND CAPVERDISCHE INSELN

1. *Læmophlœus axillaris* Woll., Madera.
2. *Læmophlœus clavicollis* Woll., Madera.
3. *Læmophlœus donacioides* Woll., Madera.
4. *Læmophlœus granulatus* Woll., Madera.
5. *Læmophlœus politissimus* Woll., Cap Verde.
6. *Læmophlœus stenoides* Woll., Madera.

V. BOLIVIA

1. *Læmophlœus germaini* Gr. 2. *Læmophlœus nigrifrons* Gr.
3. *Rhinomalus fulvicollis* Gr.

VI. BORNEO

1. *Læmophlœus lepidus* Gr. 2. *Læmophlœus ovalis* Gr.

VII. BRASILIEN

1. *Læmophlœus aeneus* Gr.
2. *Læmophlœus castaneipennis* Gr.
3. *Læmophlœus curtus* Gr.
4. *Læmophlœus deletus* Gr.
5. *Læmophlœus grouvellei* Gr.
6. *Læmophlœus impressus* Gr.
7. *Læmophlœus lacerdae* Gr.
8. *Læmophlœus mathani* Gr.
9. *Læmophlœus megacephalus* Gr.
10. *Læmophlœus mixtus* Gr.
11. *Læmophlœus ovipennis* Rtt.
12. *Læmophlœus pallidipennis* Rtt.
13. *Læmophlœus pallentipennis* Grouv.
14. *Læmophlœus pilatei* Gr.
15. *Læmophlœus quinquearticulatus* Gr.
16. *Læmophlœus reitteri* Gr.
17. *Læmophlœus repandus* Rtt.
18. *Læmophlœus stramineus* Rtt.
19. *Læmophlœus straminipennis* Rtt.
20. *Læmophlœus uncicornis* Rtt.
21. *Rhinomalus elegans* Gr.
22. *Rhinomalus facetus* Gr.
23. *Rhinomalus ruficollis* Gr.
24. *Rhinomalus unifasciatus* Gr.
25. *Rhinophlœus productus* Gr.
26. *Rhinophlœus salpingoïdes* Gr.

VIII. CEYLON

1. *Læmophlœus atratulus* Gr.
2. *Læmophlœus coloratus* Gr.
3. *Læmophlœus divaricatus* Gr.
4. *Læmophlœus foveolatus* Rtt.
5. *Læmophlœus hypocrita* Gr.
6. *Læmophlœus insinuans* Gr.
7. *Læmophlœus orientalis* Gr.
8. *Læmophlœus subtestaceus* Gr.

IX. COLUMBIA

1. *Læmophlœus castaneipennis* Gr.
2. *Læmophlœus germaini* Gr.
3. *Læmophlœus iteratus* Shp.
4. *Læmophlœus lucanoïdes* Smith.
5. *Læmophlœus macrognathus* Rtt.
6. *Læmophlœus megacephalus* Gr.
7. *Læmophlœus pallentipennis* Gr.
8. *Læmophlœus recticollis* Rtt.
9. *Læmophlœus semiaeneus* Rtt.
10. *Læmophlœus semiflavus* Rtt.
11. *Læmophlœus seminiger* Rtt.
12. *Læmophlœus suturalis* Rtt.

X. WESTINDISCHEN INSELN, CUBA, ETC.

1. *Læmophlœus bicolor* Chevr.
2. *Læmophlœus chevrolati* Gr.
3. *Læmophlœus commixtus* Gr., Guadeloupe.
4. *Læmophlœus dufani* Gr., Guadeloupe.
5. *Læmophlœus exquisitus* Gr., Guadeloupe.
6. *Læmophlœus pallentipennis* Gr.
7. *Læmophlœus permixtus* Gr.
8. *Læmophlœus uncicornis* Rtt.

XI. EUROPA

1. *Læmophlœus abietis* Wankow., Nord-Europa, Mittel-Europa.
2. *Læmophlœus ater* Ol., Mittel-Europa, Süd-Europa.
3. *Læmophlœus* var. *capensis* Waltl, Mittel-Europa, Süd-Europa.
4. *Læmophlœus bimaculatus* Payk., Nord-Europa, Mittel-Europa.
5. *Læmophlœus brevicornis* Thoms., Nord-Europa.
6. *Læmophlœus castaneus* Er., Mittel-Europa, Süd-Europa.
7. *Læmophlœus clematidis* Er., Mittel-Europa, Süd-Europa.
8. *Læmophlœus corticinus* Er., Nord-Europa, Mittel-Europa.
9. *Læmophlœus duplicatus* Waltl, Süd-Europa.
10. *Læmophlœus emgei* Rtt., Süd-Europa.
11. *Læmophlœus fractipennis* Motsch., Süd-Europa.
12. *Læmophlœus hypobori* Perris, Mittel-Europa, Süd-Europa.
13. *Læmophlœus infuscatus* Motsch., Ost-Europa.
14. *Læmophlœus juniperi* Gr., Süd-Europa.
15. *Læmophlœus kraussi* Gglb., Mittel-Europa.
16. *Læmophlœus monilis* Fabr., Nord-Europa, Mittel-Europa.
17. *Læmophlœus muticus* Fabr., Nord-Europa, Mittel-Europa.
18. *Læmophlœus nigricollis* Luc., Mittel-Europa, Süd-Europa, Ost-Europa.
19. *Læmophlœus perrisi* Gr., Korsika.
20. *Læmophlœus puncticollis* Fleischer, Nord-Europa.
21. *Læmophlœus steppensis* Motsch., Ost-Europa.
22. *Læmophlœus weisei*, Nord-Europa.

XII. GUATEMALA

1. *Deinophloeus ducalis* Shp.
2. *Læmophlœus addendus* Shp.
3. *Læmophlœus alticola* Shp.
4. *Læmophlœus annectens* Shp.
5. *Læmophlœus boops* Shp.
6. *Læmophlœus celatus* Shp.
7. *Læmophlœus championi* Shp.
8. *Læmophlœus clavicornis* Shp.
9. *Læmophlœus convexus* Gr.
10. *Læmophlœus corporalis* Shp.
11. *Læmophlœus distans* Shp.
12. *Læmophlœus distinguendus* Shp.
13. *Læmophlœus endomychus* Shp.
14. *Læmophlœus flavescens* Shp.
15. *Læmophlœus frequens* Shp.
16. *Læmophlœus germaini* Gr.
17. *Læmophlœus guatemalenus* Shp.
18. *Læmophlœus hoplites* Shp.
19. *Læmophlœus ignobilis* Shp.
20. *Læmophlœus incisus* Shp.
21. *Læmophlœus insolitus* Shp.
22. *Læmophlœus inusitus* Shp.
23. *Læmophlœus iteratus* Shp.
24. *Læmophlœus optatus* Shp.
25. *Læmophlœus pallentipennis* Gr.
26. *Læmophlœus puncticollis* Shp.[3]
27. *Læmophlœus recticollis* Rtt.
28. *Læmophlœus suturalis* Rtt.
29. *Parandrita capito* Gr.
30. *Parandrita deceptor* Shp.
31. *Parandrita stipes* Shp.

[3] Da der Name *puncticollis* von Fleischer bereits (1829) für eine europäische *Læmophlœus*-Art vergeben wurde, wird an Stelle des Sharp'schen Namens ein anderer zu treten haben.

XII. GUATEMALA—Continued

32. *Rhabdophlœus concolor* Shp.
33. *Rhabdophlœus costatus* Shp.
34. *Rhabdophlœus dispar* Shp.
35. *Rhinomalus signatus* Shp.
36. *Rhinophlœus gracilis* Shp.
37. *Rhinophlœus nasutus* Shp.
38. *Rhinophlœus productus* Gr.
39. *Rhinophlœus salpingoides* Gr.
40. *Silvanophlœus bembidium* Shp.
41. *Silvanophlœus cognatus* Shp.
42. *Silvanophlœus fraudator* Shp.
43. *Silvanophlœus gundlachi* Shp.
44. *Silvanophlœus infimus* Shp.

XIII. HONDURAS

1. *Læmophlœus iteratus* Shp.
2. *Læmophlœus pallentipennis* Gr.
3. *Læmophlœus recticollis* Rtt.
4. *Silvanophlœus gundlachi* Gr.

XIV. HINTER-INDIEN

1. *Læmophlœus carinicollis* Gr.
2. *Læmophlœus invertus* Gr.
3. *Læmophlœus lepidus* Gr.
4. *Læmophlœus mandibularis* Gr.
5. *Læmophlœus rugifrons* Gr.
6. *Læmophlœus spinosus* Gr.
7. *Læmophlœus subtestaceus* Gr.

XV. VORDER-INDIEN

1. *Læmophlœus belli* Gr.
2. *Læmophlœus calognathus* Gr.
3. *Læmophlœus ditomoïdes* Gr.
4. *Læmophlœus dorcoïdes* Rtt.
5. *Læmophlœus falcidens* Gr.
6. *Læmophlœus harmandi* Gr.
7. *Læmophlœus incertus* Gr.
8. *Læmophlœus indicus* Gr.
9. *Læmophlœus interceptus* Gr.
10. *Læmophlœus faneti* Gr.
11. *Læmophlœus neglectus* Gr.
12. *Læmophlœus picipennis* Gr.
13. *Læmophlœus sanguinolentus* Hope.

XVI. JAPAN

1. *Læmophlœus convexiusculus* Gr.
2. *Læmophlœus dorcoïdes* Rtt.
3. *Læmophlœus laevior* Rtt.
4. *Læmophlœus nigrofasciatus* Rtt.

XVII. JAVA

1. *Læmophlœus incertus* Gr.

XVIII. KOSMOPOLITEN

1. *Læmophlœus alternans* Erichs.
2. *Læmophlœus ferrugineus* Steph.
3. *Læmophlœus minutus* Ol.
4. *Læmophlœus turcicus* Gr.
5. *Silvanophlœus testaceus* Fabr.

XIX. MADAGASKAR UND REUNION

1. *Læmophlœus allnaudi* Gr., Madagaskar.
2. *Læmophlœus atratulus* Gr., Madagaskar und Reunion.
3. *Læmophlœus brevipennis* Gr., Madagaskar.
4. *Læmophlœus coquereli* Gr., Madagaskar und Reunion.
5. *Læmophlœus cornutus* Gr., Madagaskar.
6. *Læmophlœus fairmairei* Gr., Madagaskar.
7. *Læmophlœus faneti* Gr., Madagaskar.
8. *Læmophlœus mirificus* Gr., Reunion.

XIX. MADAGASKAR UND REUNION—Continued

9. *Læmophlœus mirus* Gr., Madagaskar.
10. *Læmophlœus perrieri* Gr., Madagaskar.
11. *Læmophlœus planulatus* Gr., Reunion.
12. *Læmophlœus raffrayi* Gr., Madagaskar.
13. *Læmophlœus sulcifrons* Gr., Reunion.
14. *Læmophlœus tenebrosus* Gr., Reunion.

XX. MEXICO

1. *Deinophlœus ducalis* Shp.
2. *Læmophlœus amulae* Shp.
3. *Læmophlœus hoplites* Shp.
4. *Læmophlœus ignobilis* Shp.
5. *Læmophlœus iteratus* Shp.
6. *Læmophlœus minusculus* Gr.
7. *Læmophlœus pallentipennis* Gr.
8. *Læmophlœus pauper* Shp.
9. *Læmophlœus recticollis* Rtt.
10. *Læmophlœus suturalis* Rtt.
11. *Læmophlœus suturalis* var. *circumdatus* Shp.
12. *Læmophlœus teapensis* Grouv.
13. *Læmophlœus uncicornis* Rtt.
14. *Parandrita capito* Gr.
15. *Parandrita stipes* Shp.
16. *Rhabdophlœus concolor* Shp.
17. *Rhabdophlœus costatus* Shp.
18. *Rhinomalus anthracinus* Shp.
19. *Rhinomalus chiriquensis* Shp.
20. *Rhinomalus vicinus* Gr.
21. *Rhinophlœus nasutus* Shp.
22. *Rhinophlœus productus* Gr.
23. *Rhinophlœus salpingoides* Gr.
24. *Silvanophlœus gundlachi* Gr.

XXI. NICARAGUA

1. *Læmophlœus ignobilis* Shp.
2. *Læmophlœus pallentipennis* Gr

XXII. PANAMA

1. *Læmophlœus anticus* Shp.
2. *Læmophlœus breviceps* Shp.
3. *Læmophlœus carabinus* Shp.
4. *Læmophlœus convexus* Gr.
5. *Læmophlœus curtus* Gr.
6. *Læmophlœus distinguendus* Shp.
7. *Læmophlœus dives* Shp.
8. *Læmophlœus frequens* Shp.
9. *Læmophlœus immersus* Shp.
10. *Læmophlœus incisus* Shp.
11. *Læmophlœus minutus* Shp.[1]
12. *Læmophlœus pallentipennis* Gr.
13. *Læmophlœus striatus* Shp.
14. *Læmophlœus suturalis* Rtt.
15. *Deinophlœus sinuatus* Shp.
16. *Rhabdophlœus chiriquensis* Shp.
17. *Rhinomalus chiriquensis* Shp.
18. *Silvanophlœus atomarius* Shp.
19. *Silvanophlœus gundlachi* Gr.

XXIII. PHILIPPINEN

1. *Læmophlœus philippinicus* Kess.

XXIV. SUMATRA

1. *Læmophlœus atratulus* Gr.
2. *Læmophlœus decoratus* Gr.
3. *Læmophlœus incertus* Gr.
4. *Læmophlœus mandibularis* Gr.
5. *Læmophlœus proximus* Gr.
6. *Læmophlœus subtestaceus* Gr.

[1] Der Name *minutus* ist bereits (1791) von Olivier für eine kosmopolitische *Læmophlœus*-Art vergeben. Cf. Bemerkung sub. XII, 26.

XXV. VENEZUELA

1. *Læmophlœus albofasciatus* Gr.
2. *Læmophlœus castaneipennis* Gr.
3. *Læmophlœus pallentipennis* Gr.
4. *Læmophlœus obliquefasciatus* Gr.

XXVI. VEREINIGTE STAATEN VON NORD-AMERIKA

1. *Dysmerus basalis* Casey (vielleicht Synonym zu *Læmophlœus uncicornis* Rtt.).
2. *Læmophlœus adustus* Lec.
3. *Læmophlœus angustulus* Lec.
4. *Læmophlœus biguttatus* Say.
5. *Læmophlœus cephalotes* Lec.
6. *Læmophlœus chamaeropsis* Schwarz, Süd-Amerika.
7. *Læmophlœus convexulus* Lec.
8. *Læmophlœus denticornis* Casey.
9. *Læmophlœus extricatus* Casey.
10. *Læmophlœus fasciatus* Melsch.
11. *Læmophlœus floridanus* Casey.
12. *Læmophlæus horni* Casey.
13. *Læmophlœus lecontei* Gr.
14. *Læmophlœus longicornis* Mannh.
15. *Læmophlœus modestus* Say.
16. *Læmophlœus puberulus* Lec.
17. *Læmophlœus pubescens* Casey.
18. *Læmophlœus punctatus* Lec.
19. *Læmophlœus quadratus* Casey.
20. *Læmophlœus rotundicollis* Casey.
21. *Læmophlœus schwarzi* Casey.
22. *Læmophlœus terminatus* Casey.
23. *Læmophlœus truncatus* Casey.
24. *Silvanophlœus niteus* Lec.

Die Aufstellung zeigt, dass einzelne Regionen, besonders Ost-Asien, in Bezug auf *Læmophlœus*-Arten noch sehr wenig

FIG. 1. *Læmophlœus* (*Brontophlœus*) *uncicornis* Rtt.; *a*, Fühler des Männchens; *b*, Fühler des Weibchens.

durchforscht sind. Dankbar wäre ich, wenn Museen und Privat-Sammler, welche diese Zeilen lesen, meine Studien durch Mitteilung von Fundorten unterstützen wollten. Auch benötige ich für meine anatomischen Arbeiten sehr viel Material, für das ich im Tausch gegebenen Falle brasilianische Coleoptera oder Lepidoptera abgebe.

ILLUSTRATION

TEXTFIG. 1. *Læmophlæus* (*Brontophlæus*) *uncicornis* Rtt.; *a*, Fühler des Männchens; *b*, Fühler des Weibchens.

NOUVEAUX CERCOPIDES DES PHILIPPINES

Par V. LALLEMAND

Uecle, Bruxelles

Genus **PHYMATOSTETHA** Stål

Phymatostetha rubens sp. nov.

Tête, pronotum, écusson sont rouge-brique, élytres rouge-brique, devenant rouge-jaunâtre à la partie réticulée; sur le vertex, à sa base, entre les yeux, une ligne transversale, sur le pronotum les 2 fossettes situées en arrière des yeux, une fine bande longitudinale et 4 taches sur les élytres sont noirâtres. Le front près des yeux est légèrement brunâtre. Voici la disposition des bandes et taches, des élytres: la bande longitudinale s'étend depuis la base sur le tiers antérieur le long du radius; près du bord externe, de suite aprés le milieu, se trouve une première tache s'étendant jusqu'au médian et ayant deux pointes vers l'arrière, entre le médian et le cubitus se trouve la deuxième qui est arrondie; en avant de la partie réticulée se trouvent les taches 3 et 4 une au bord externe et l'autre en arrière de la tache no 2. Les ailes sont enfumées, a base rosée. Rostre, thorax noirs (sauf l'extrémité des protubérances et les hanches rouges) pattes rouges, sauf le milieu des cuisses et les épines des tarses postérieurs qui sont brunes. Le premièr segment de l'abdomen est noir bordé de rouge, les autres sont rouges portant de chaque côté une tache transversale noire, la base des organes génitaux et la tarrière sont noires; la partie supérieure de l'abdomen est rouge. Pronotum fortement et grossièrement ponctué en séries transversales, la carêne longitudinale est peu marquée, son bord postérieur est concave, arrondi. Le mésothorax présente deux protubérances en avant des hanches médianes, dont la face antérieure est en pente, tandis que la face postérieure tombe droit. Longueur totale, 17 mm.; longueur des élytres, 13 mm.

LUZON, Laguna, Mount Maquiling (*Baker*).

Phymatostetha dapitana sp. nov.

Espèce voisine de *P. mactans* White et surtout de *flavopicta* Distant. La tête est jaune sauf une bande transversale entre

les yeux à la base du vertex et une tache de chaque côté du front au devant des yeux, qui sont noirs. Le pronotum est jaune portant 2 larges bandes longitudinales noires n'atteignant pas le bord antérieur; écusson noir. Elytres noirs, ils ont 3 bandes et 3 taches jaunes, une large bande droite sur le clavus longeant le bord interne jusque vers la naissance de la pointe de l'écusson, puis s'en écartant elle est plus large à son extrémité qu'a la base; une deuxième bande le long du bord externe s'étendant aussi loin que la première; un peu en arrière de ces 2 premières se trouve une bande transversale légèrement ondulée, quant aux taches, les 2 premières sont situées en avant de la partie réticulée, une au bord externe et l'autre au bord interne vers la pointe du clavus, la troisième se trouve en arrière de celles-ci, au milieu; les ailes sont noirâtres; l'abdomen est jaune-foncé à sa face supérieure, à sa face inférieure le premier segment est noirâtre bordé de jaune-foncé et les autres sont jaune-foncé portant 4 taches noires, 2 petites triangulaires á la base et au milieu, et une grosse tache de chaque côté; la base des organes génitaux et la tarriére sont noirâtres. Longueur totale, 19 mm.; longueur des élytres, 15 mm.

MINDANAO, Dapitan (*Baker*).

Phymatostetha cincta sp. nov.

Espèce voisine de *Phymatostetha circumducta* Walker, *ståli* Butler, et *hilaris* Walker.

La tête est noire sauf les parties latérales du vertex et une tache triangulaire frontale qui sont jaunes; pronotum noir sauf une bande jaune le long des bords antérieurs et latéro-antérieurs, la bande antérieure est de dimensions inégales, large au milieu, elle se rétrécit sur les côtés, en effet les fossettes latérales du pronotum (qui se trouvent en arrière des yeux) occupent cette bande et sont de la même couleur que le disque; l'écusson est noir, une bande jaune occupe le tiers basal. Les élytres brun-noir sont recouvertes d'une villosité dense et jaune-gris, sur celles-ci se voient 2 bandes transversales, deux bandes longitudinales et une fine bordure jaunâtre. La première bande transversale se trouve en avant du milieu et le dieuxème au devant de la partie réticulée; la bande longitudinale sur le clavus longe le bord interne; elle s'étend jusqu'au niveau du milieu de l'écusson, la dieuxème longeant le bord externe se rétrécit brusquement un peu en avant de la première bande transversale et sous la forme d'un mince filet borde l'élytre jusqu'a la pointe du clavus. Les ailes sont enfumées à base rougeâtre. Thorax ocre-jaune

sauf les protubérances qui sont noires. Pattes jaune-brunâtre, sur les cuisses se trouvent 2 bandes longitudinales, noires et la moitié apicale des tibias est foncée, l'abdomen est bleu-violet à sa partie supérieure et jaunâtre à sa partie inférieure, sauf le premier segment qui est noirâtre mais bordé de jaune et une tache noire de chaque côté sur chaque segment.

Un exemplaire que je possede de Balabac a les dessins rouges au lieu de jaunes comme pour ceux de Palawan.

La surface du pronotum est rugueuse densement et grossièrement striée en lignes transversales, elle porte une carêne longitudinale commençant à une certaine distance du bord antérieur; l'écusson porte une fossette centrale, sa surface est transversalement striée; les ocelles sont très proches l'un de l'autre, la distance qui les sépare des yeux est égale à trois fois leur écartement. La face est globuleuse transversalement striée; les protubérances du mésothorax sont situées au devant des hanches médianes elles sont peu élevées, transversales. Longueur totale, 14 mm.; longueur des élytres, 10.5 mm.

Cette espèce se distingue de *P. ståli* Butler et *hilaris* Walker par la coloration du vertex, par la forme de la bande antérieure du pronotum et par la bande de l'écusson.

PALAWAN. BALABAC.

Type.—La collection du musée de Paris (Ile Palawan) et ma collection (Balabac).

Phymatostetha iligana sp. nov.

L'insecte est tout noir sauf les taches ou bandes dont la description suit et qui sont jaunes; le bord antérieur du vertex se prolongeant en une tache triangulaire jaune-brun sur le front, les bords antérieurs et latéro-antérieurs du pronotum et une ligne longitudinale médiane; sur les élytres: une bande transversale au devant du milieu, deux taches au devant de la partie apicale, une au bord externe et une autre à l'extrémité du clavus, enfin une troisième au milieu de la partie apicale, une bande longitudinale s'étendant sur le subcosta mais n'atteignant pas la bande transversale, sur le clavus une bande droite partant de la base, longeant le bord interne jusqu'à l'extrémité du pronotum, puis s'en écartant, le bord interne lui-même jusqu'á la première bande transverse est rougeâtre; les ailes ont leur base rougeâtre. A l'extrémité du front, près du clypeus existe de chaque côté une tache jaune; les hanches et la base des cuisses, de même que l'extréme bord de chaque segment, abdominaux sont également jaunes; les protubérances du mésothorax sont bien développées,

leur extrémité est plus claire. Longueur totale, 16 mm.; longueur des élytres, 12 mm.

Cette espèce, par le dessin des élytres est voisine de *P. mactans* White, *flavopicta* Distant, *dapitana* sp. nov.

MINDANAO, Iligan (*Baker*).

Genus **LEPTATASPIS** Schmidt

Leptataspis butuanensis sp. nov.

L'insecte est noir, sauf une bande transversale rouge qui occupe à peu près le quart basal des élytres et dont le bord postérieur n'est pas droit, la bande s'étend un peu plus en arrière a la partie externe de l'élytre, en dehors du radius; la base des ailes est également rougeâtre. Les élytres sont longues à peu près 3 fois leur largeur (16 mm x 6 mm) le médian et le cubitus sont réunis sur le tiers basal.

La surface du pronotum est lisse, brillante, finement ponctuée, portant une carêne dans sa partie antérieure, celle-ci se continue par un sillon à la partie postérieure. Les ocelles sont à égale distance l'un de l'autre.

Le rostre s'étend jusqu'entre les hanches médianes; les protubérances du mésothorax sont transverses et non en cône, légérement dirigées en avant, le bord postérieur du mésothorax est foliacé. Longueur totale, 20 mm.; longueur des élytres, 16 mm.; largueur des élytres, 6 mm.

MINDANAO, Agusan, Butuan (*Baker*).

Leptataspis bukidnona sp. nov.

Ecusson, pronotum tête et thorax rouge-brun, brillants; moitié basale des élytres ocre-jaune, moitié apicale noire. Sur la partie antérieure existent 8 taches noires, une près de la base sur le médian et une seconde sur la première nervure du clavus non loin de la base, ensuite une bande transversale composée de 4 taches, une prés du bord externe, une deuxiéme sur le tronc commun du médian et du cubitus et 2 sur le clavus, séparées par la première nervure; enfin une seconde bande composée de 2 taches, la première près du bord externe, au devant de la bifurcation du radius, la dieuxième entre le médian et le cubitus bifurqués; l'abdomen est noir. Toute la surface de l'insecte est recouverte d'une villosité noire. Le médian, le cubitus sont réunis sur le tiers basal des élytres.

La surface du pronotum est lisse et brillante finement ponctuée, sur la moitié antérieure du pronotum existe une carêne médiane qui se continue par un fin sillon, les protubérances du

mésothorax sont bien développées, transversales, son bord postérieur est foliacé. Longueur totale, 19 mm.; longueur des élytres, 14 mm.; largeur des élytres, 5.5 mm.

MINDANAO, Bukidnon, Tangcolan (*Baker*).

Genus **OPISTARSOSTETHUS** Schmidt

Opistarsostethus calypso sp. nov.

Tête, pronotum, pattes antérieures, l'extrême base et le tiers antérieur du bord externe des élytres sont rouge brique. Tibias et tarses médians et postérieurs brun-rougeâtre, tout le restant de l'insecte est noir sauf 7 petites taches rouge-clair sur les élytres, les 4 premières sont placées en une série transversale au devant du milieu, la première très petite est située près du bord externe, la dieuxième de même dimension et très voisine de la première, près du radius, la troisième entre la médian et le cubitus, la quatrième sur le clavus. Les 3 autres se trouvent au devant de la partie réticulée, une au bord externe, la dieuxième entre le radius II et le médian, la troisième transversale près de la pointe du clavus sur le cubitus.

La surface du pronotum est quelque peu rugueuse, transversalement et fortement ponctuée, elle montre une carène médiane très nette, son bord postérieur est anguleux et concave, les angles latéraux sont arrondis, sur les élytres le médian et le cubitus sont réunis par un rameau transversal. Le rostre s'étend jusqu'au devant des hanches médianes. Les protubérances du mésothorax sont transversales, son bord postérieur est foliacé. Longueur totale, 21 mm.; longueur des élytres, 17 mm.; largeur des élytres, 6.5 mm.

POLILLO (*Edward H. Taylor*).

Genus **RADIOSCARTA** novum

Front dans son ensemble assez globuleux, partagé en 3 parties nettes, une médiane et 2 latérales séparées par des carènes èmoussées, la partie médiane est très légérement et transversalement bombée a sillons transversaux peu marqués, sans carène ni sillon longitudinal médian. Vu de côté et dans le sens de la longueur, le bord antérieur est légèrement incurvé, le postérieur est droit et l'angle formé est un peu plus grand que le droit. Le rostre assez long s'étend jusque près des hanches médianes. Les élytres ont le bord externe convexe, leur plus grande largeur est située vers la fin du tiers antérieur, le médian et le cubitus ne sont pas soudés, ils sont réunis par un rameau oblique. Sur les ailes,

le rameau transverse réunissant le dieuxième au troisième secteur est situé bien en avant de la bifurcation du troisième secteur. La partie antérieure du pronotum et le vertex sont déclives, la distance séparant les ocelles des yeux est le double de leur écartement, le vertex est plus large que long. Le pronotum a ses angles latéraux arrondis, il porte une fine carêne longitudinale. L'écusson est creusé en une fossette médiane. Le mésothorax est sans protubérance, en bourrelet transversal. Les tibias postérieurs ont 2 épines, une petite à la base, et une forte au milieu.

Type du genre, *Radioscarta surigaona* sp. nov.

Radioscarta surigaona sp. nov.

L'insecte est tout brun, sauf le mésothorax qui est ocre-jaune. Le milieu du front, le bord latéral du vertex et une tache au devant des ocelles ainsi que 2 petites taches près du bord postérieur sont jaunes. Sur le pronotum chez la femelle existe une fine ligne transversalé ondulée jaune, tandis que chez le mâle existe une large bande transversale jaune, qui occupe à peu près toute la moitié antérieure, mais qui ne s'étend pas jusqu'au bord antérieur: la pointe de l'écusson est jaunâtre; sur les élytres se voit au devant du milieu une ligne transversale plus ou moins droite composée de 7 taches blanches, 5 sur le corium et 2 sur le clavus, au devant de la partie réticulée existent 2 taches transversales, une au bord externe et l'autre à l'extrémité du clavus, un peu en arrière de celles-ci et sur le milieu se trouve une troisième tache arrondie. Les ailes sont enfumées, les nervures sont noires; la tête est arrondie à son bord antérieur; pronotum densement ponctué, ses bords antérieurs sont droits, son bord postérieur est concave et arrondi, l'angle latéral est arrondi, les tibias postérieurs ont 2 épines. Mâle, longueur totale, 10.5 mm.; longueur des élytres, 8.5 mm.; largeur des élytres, 3 mm. Femelle, longueur totale, 8 mm.; longueur des élytres, 6.5 mm.; largeur des élytres, 2.5 mm.

MINDANAO, Surigao, Surigao (*Baker*).

Genus **EUGLOBICEPS** novum

Front globuleux, arrondi lisse à sillons peu marqués à la partie médiane, la forme de la tête rappelle le genre *Abidama* Distant, la longueur de la partie visible d'en haut est plus grande que la largeur de la partie du vertex comprise entre les yeux; les ocelles sont petits, plus près l'un de l'autre que des yeux et séparés par une carêne; le vertex et la partie frontale du vertex sont plats, à bord antérieur arrondi: pronotum un peu rugueux, à

fossettes antérieures, bord latéro-antérieur droit, bord postérieur un peu concave arrondi, il n'a pas de carêne. Ecusson à fossette médiane. Sur le tiers basal des élytres le médian et le cubitus sont réunis, les nervures sont relativement peu marquées, le réseau apical est bien visible mais peu saillant, la longueur des élytres est a peu près ègale á 3 fois leur largeur, l'endroit le plus large est au devant de la partie apicale réticulée, le mésothorax est bombé transverse, sans protubérances. Le rostre à 2 articles d'égale longueur et s'étend jusqu'entre les hanches médianes. Les cuisses antérieures et médianes montrent une fossette longitudinale occupant à peu près toute la longeur et rappelant celle du genre *Notoscarta* Breddin. Les tarses postérieures n'ont qu'une épine.

Type du genre, *Euglobiceps elongata* sp. nov.

Euglobiceps elongata sp. nov.

Toute la surface de l'insecte, spécialement les élytres et le pronotum, est recouvert d'une villosité dense jaune-gris. Tête d'un brun-acajou, pronotum, écusson (sauf l'extrémité, rouge) élytres brunes, thorax rose, abdomen rose sauf les 2 derniers segments et les organes génitaux (sauf la base de la tarrière, rose) qui sont brunâtres; pattes roses sauf les tibias et les tarses antérieurs et médians, les épines et les tarses postérieurs. Longueur totale, 8 mm.; longueur des élytres, 6 mm.

MINDANAO, Dapitan (*Baker*).

Genus **EUBAKERIELLA** novum

Pronotum rugueux, grossièrement ponctué, à carêne médiane, à bord postérieur fortement convexe arrondi.

Ecusson allongé, effilé: élytres à nervures très fortement saillantes, médian et cubitus réunis sur un court trajet, sur toute la surface de l'élytre existent des rameaux transverses.

Les protubérances du mésothorax sont bien développées, légèrement transverses, son bord postérieur est foliacé. Les ocelles sont petits, à distance égale l'un de l'autre et des yeux, la partie frontale du vertex est nettement séparée du vertex par des sillons et elle se continue sans interruption avec le front qui est globuleux et dont la surface montre des sillons transversaux. Ce genre est voisin de *Phlebarcys* Schmidt par les nervures saillantes, qui occupent à peu près toute la surface de l'élytre (corium et clavus); il s'en distingue également par la forme du front et le bord postérieur du pronotum qui est convexe.

Type du genre, *Eubakeriella spectabilis* sp. nov.

Eubakeriella spectabilis sp. nov.

Elytres brunes à reflets métalliques verdâtres sur les 2 tiers antérieurs. Pronotum brun à légers reflets verts, bord antérieur noir-vert et les autres bords sont ocre-jaune; tête noire à reflets verts, clypeus, rostre, pattes, tarrière du mâle jaunes, thorax noir (sauf une bande latérale jaune du mésothorax) ; l'abdomen est noir, à reflets bleus métalliques à la face supérieure et verts à la face inférieure. Toute la surface de l'insecte est recouverte d'une villosité grise spécialement à la face inférieure. Longueur totale, 18 mm.; longueur des élytres , 8 mm.; largueur des élytres, 3 mm.

SUMATRA (*Corporaal*).

EFFECTS OF EXTRACTS OF ASCARIS VITOLORUM ON EXPERIMENTAL ANIMALS

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INTRODUCTION

During the past few months a number of calves (Indian buffalo and native carabao) of the herd of the College of Agriculture died as a result of heavy infestation with *Ascaris vitolorum*, a species of rather common occurrence in bovine animals in the Philippine Islands. The animals in question exhibited severe symptoms, which became more intense following the administration of turpentine as an anthelminthic. As a result of anthelminthic medication the parasites were killed; but, despite the administration of rather heavy doses of castor oil, they were not eliminated from the intestine, as was shown by post-mortem examination.

The symptoms exhibited by the sick calves were those of extreme weakness combined with a rather pronounced toxæmia. Shortly before death the animals exhibited severe nervous reactions, such as vertigo and epilepsy, these symptoms being followed by complete prostration and death.

Post-mortem examination revealed numerous worms, many of which were dead, in the duodenum, a few worms in the stomach, and partially digested worms as well as fragments of worms in different portions of the intestines. Whether the death and resultant disintegration of the worms were responsible for the increase in the severity of the symptoms following the administration of turpentine could not be determined, because the sick animals were treated before I had an opportunity to keep one or more untreated animals as controls. Since the behavior of the sick calves before the administration of anthelminthics was indicative of toxæmia, it occurred to me that toxic substances, either true secretory products of the parasites or disintegration products following the death of the worms, might be responsible for the severe clinical manifestation of that parasitic condition.

The experiments herein discussed were undertaken with a view of obtaining information on that point. A more-detailed

series of experiments than those recorded in this paper was planned, but as no specimens of *Ascaris vitolorum* have been found recently, either in Los Baños or in abattoirs in Manila, I desire to record the results that have thus far been obtained.

TECHNIC

Extracts that were used in the experiments described were prepared from worms that were recovered during post-mortem examination of calves that succumbed to ascariasis. Only living specimens were selected for the purpose of preparing the extracts, and the specimens were thoroughly and repeatedly washed in physiological salt solution in order to free their surface from adhering intestinal matter. The worms were then dried with filter paper, placed in a glass dish, and cut into pieces about 2.5 centimeters long. The cut-up worms were placed in a desiccator containing calcium chloride, and after several days' drying the parasite material was sufficiently crisp to allow pulverization.

Extracts were prepared in physiological salt solution (0.85 per cent solution of sodium chloride) by suspending a certain quantity of triturated worm material in a certain quantity of salt solution, as noted in connection with each series of experiments, and allowing the mixture to remain in a cool, dark place for from two to three hours. The mixtures were then filtered, or the fluid was removed by means of a syringe without filtration.

Unless otherwise stated, animals were injected intraperitoneally, and the usual aseptic precautions were adhered to in the course of these experiments. All animals used in the experiments were full grown.

RECORDS OF EXPERIMENTS

SERIES I

The following extract was used in this series of experiments: One gram of finely powdered worm material was suspended in 10 cubic centimeters of physiological salt solution.

Experiment 1.—One and five-tenths cubic centimeters of the filtered extract was injected into guinea pig 1. About fifteen minutes after the injection the animal gave evidence of distress. The following symptoms were most pronounced: Severe scratching, marked trembling and excitation, and a rough coat. These symptoms gradually increased in severity and were followed by weakness in the legs, a tendency to fall down, and finally by paralysis. The animal was kept under observation for several

hours, during which period the symptoms did not subside. The following day the animal was found dead.

Experiment 2.—Guinea pig 2 was injected with the same quantity of extract as was used in experiment 1. The appearance and persistence of symptoms and the results were the same as in experiment 1.

SERIES II

The following extract was used in the experiments of this series: One gram of powder was suspended in 15 cubic centimeters of physiological salt solution.

Experiment 3.—Guinea pig 3 was injected with 1 cubic centimeter of extract. The symptoms were practically the same as those noted in experiment 1. There was a period during which the animal showed evidence of distress by running excitedly up and down the table and emitting shrill sounds from time to time. This was followed by a state of dullness and stupor, and complete prostration. This animal gradually recovered from the injection. It was kept under observation for several weeks, but showed no further symptoms.

Experiment 4.—Guinea pig 4 was injected with a quantity of extract equal to that used in experiment 3, but the extract was heated to boiling point and then allowed to cool before it was injected. The results were similar to those noted in experiment 3.

Experiment 5.—Guinea pig 5 was injected with 2 cubic centimeters of extract. It exhibited the same symptoms as guinea pigs 3 and 4, but its reactions were more pronounced. This animal was found dead the next morning.

Experiment 6.—Guinea pig 6 was given 5 cubic centimeters of extract by mouth. The animal became ill immediately after the administration of the extract, ran about excitedly along the table, squealed as if in pain, scratched its face violently, rubbed its mouth with its forelegs, and exhibited other nervous symptoms. The animal eventually recovered.

SERIES III

The powdered-worm material that was used in this and in the following series of experiments was obtained from the same lot of dried worms as was that used in Series I and II. Several months elapsed between the experiments in the first two series and those in subsequent series, and during the intervals the dried-worm material was kept in a tightly corked bottle in a dark place.

The extract used in this series of experiments was made up as follows: One-half gram of powdered-worm material was extracted in 10 cubic centimeters of physiological salt solution.

Experiment 7.—Guinea pig 7 was injected with 2 cubic centimeters of the extract. About five minutes after the injection the animal began to exhibit signs of uneasiness. Its fur became rough, its movements were spasmodic, and it ran about on the table very excitedly, emitting guttural sounds. Ten minutes later it showed weakness in the legs, and shifted its weight from side to side. Its eyes were only half open, and it fell down from time to time. About thirty minutes after the injection the guinea pig was completely prostrated. It remained under close observation for seven hours and throughout this period was very ill. Its respiration was rapid and shallow, and it was feverish and extremely sensitive to touch. Frequently it squealed as if in pain. The following day the guinea pig was quiet but rather weak. It refused food and drink. Gradually, however, the animal recovered fully from the effects of the injection.

Experiment 8.—Guinea pig 8 was injected with 3 cubic centimeters of the extract. The behavior of this animal was similar to that of guinea pig 7, but the symptoms appeared more rapidly and were more marked. This animal was very ill the day after the injection, but it finally recovered.

SERIES IV

The extract used in this series of experiments, which were performed about three weeks later than the experiments in Series III, was similar to that used in experiments 7 and 8. White rats were substituted for guinea pigs in experiments 9 and 10.

Experiment 9.—Rat 1 was injected with 1.4 cubic centimeters of the extract. Ten minutes after injection the animal became greatly excited, jumped up and down in the glass jar in which it was kept under observation, and scratched itself rather violently. About ten minutes later the rat was dull and listless, its fur was rough, its back was arched, its head drooping, and respiration labored, and its body jerked involuntarily from time to time. Forty-five minutes after injection the rat lay on its abdomen. This animal was sick for an entire day, during which it was kept under close observation. It remained listless and weak. The following day the animal was weak and did not eat. It recovered from the effects of the injection in two days.

Experiment 10.—Rat 2 was injected with 1 cubic centimeter of the extract. Its reactions were the same as those described for rat 1, but the symptoms appeared more slowly.

SERIES V

Three frogs and one turtle were used in this series of experiments and extract similar to that used in Series IV was injected in quantities of 1 cubic centimeter to each animal. No definite reactions were provoked, however, the animals appearing quite unaffected by the injections.

SUMMARY OF EXPERIMENTS

Physiological salt solution extracts of *Ascaris vitolorum* were quite toxic to guinea pigs and rats. The injection of these extracts intraperitoneally resulted in the appearance of a train of morbid symptoms characterized by a stage of heightened excitability, during which the animal gave evidence of acute distress, followed by a stage of dullness, stupor, and complete prostration, with fatal termination in several cases (experiments 1, 2, and 5). Boiling the extract did not destroy its toxicity (experiment 4), and the administration of the extract by mouth produced painful reactions (experiment 6). Cold-blooded vertebrates appeared quite refractory to injection with an extract of *Ascaris vitolorum* that was toxic to rats (Series V).

DISCUSSION OF RESULTS

The results of these experiments indicate that *Ascaris vitolorum* contains a powerful, toxic substance, or more than one such substance, capable of provoking marked reactions in guinea pigs and rats. Effects produced in these animals as a result of administering salt-solution extracts of *Ascaris vitolorum* were similar to the symptoms that were shown by calves heavily infested with this parasite. Sick calves suffering from gross infestation with *Ascaris* appeared dull, listless, with head drooping, emaciated, had no appetite, and during the acute stage of the disease which led to fatal results showed marked nervous symptoms, as has already been noted in this paper.

The pathogenicity of *Ascaris vitolorum* to calves has been noted by a number of investigators whose descriptions of the symptoms of the disease suggest a chronic intoxication of the host with resultant nervous symptoms as well as digestive disturbances.

The view that the toxic symptoms in helminthiasis are due to the absorption by the host of poisonous substances elaborated by parasites has been advanced by a number of investigators, who have based their conclusions on the toxic effects produced in laboratory animals following injection with extracts of parasitic worms. So far as I am aware, the experiments described in this paper afford more conclusive evidence than has yet been offered in favor of a toxæmia in a specific parasitic disease because not only were extracts of *Ascaris vitolorum* found to be toxic, but also the reactions provoked in susceptible laboratory animals were similar to the symptoms exhibited by normally infested calves.

SUMMARY

1. Physiological salt solution extracts of *Ascaris vitolorum* were found to be toxic to guinea pigs and rats, and nontoxic to frogs and to a turtle.

2. Toxic symptoms were provoked in susceptible animals by injecting them intraperitoneally with extracts of this worm and in one case by administering an extract by mouth. In one experiment an extract was still toxic after having been boiled.

3. The symptoms exhibited by susceptible animals injected with extracts of *Ascaris vitolorum* were heightened excitability, followed by a state of dullness and prostration that led to fatal termination in several instances.

4. There was a decided similarity in symptoms exhibited by calves normally parasitized by *Ascaris vitolorum* to those provoked in susceptible animals to which extracts of that parasite were administered.

5. The data presented in this paper afford more-conclusive evidence in favor of a chemical pathology in a specific helminthic disease than has been offered heretofore.